# FORT PECK FISHERY HABITAT EVALUATION AND IMPROVEMENT STUDY

Final Milestone

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ABSTRACT

This report summarizes the results of a three year study designed to identify and evaluate the impacts of the operation of Fort Peck Dam on the downstream fishery, and to test and implement methods to overcome these impacts through improved water level management and habitat enhancement. It also recommends actions to be taken to maintain the improvements gained during the study, and to continue to develop the area for gamefish.

Fort Peck Dam historically has been operated for peaking power production. Discharges have been maintained at high levels during the day, then dropped at night, resulting in large daily water level fluctuations below the dam. This pattern was typical of historic water level fluctuations occurring below Fort Peck Dam, and had two major impacts on the downstream fishery: 1) Fluctuating water levels in the river severely inhibited rainbow trout spawning and rearing success, and, 2) Daily water level fluctuations in the tailpool and dredge cuts caused a fluctuation zone along the shoreline where shoreline or rooted aquatic vegetation could not become established. Forage and gamefish in the area lack vegetation for spawning and security cover.

A minimum instantaneous discharge (24 hours/day) of 7,800 cfs is necessary from Fort Peck Dam to maintain optimal spawning and rearing conditions for salmonids in the East Side Channel of the Missouri River. This discharge should be held from April 1 through September 30. An instantaneous discharge of 4,500 cfs is the absolute minimum acceptable for rainbow trout spawning and rearing.

The number of redds constructed by rainbow trout in the East Side Channel has increased from 187 in 1983 to 788 in 1988. This increase is a direct result of improved flow conditions and habitat enhancement measures. Increased incubation success resulted in greater numbers of young-of-the-year rainbow. Habitat enhancement measures included placement of washed and graded gravel in known spawning areas, and introduction of boulders and tree trimmings throughout the area for rearing cover. Reductions in the daily discharge fluctuations provided relatively stable flow conditions during the spawning and incubation periods.

Substrate analyses showed a rapid rate of sedimentation in the introduced gravels in the East Side Channel. Recommendations are made for controlling the sediment input to the channel.

The abundance of walleye and sauger in the area seems to be linked to various flow conditions from the dam and the Milk River. Circumstantially, high discharges from Fort Peck Dam relative to the Milk River discharge draw walleye and sauger above the Milk River to spawn. Low discharges from the dam relative to the Milk River discharge draw fish into the Milk River to spawn. Walleye and sauger spawning was documented in only one year of this study,

in 1985. Flows from Fort Peck Dam met the absolute minimum discharge recommendations 60 percent of the time that spring, the best flow year from 1983 through 1988.

The number of northern pike captured during sampling efforts fluctuated widely from year to year. Twice as many northerns were captured in 1985 than in any other year, probably a result of the improved water levels that year.

Improvements in the forage fish base of the Fort Peck tailrace and dredge cuts could substantially improve the gamefish population in the area. Attempts to improve the forage situation included introduction of cisco and spottail shiners. Rainbow smelt are abundant in some years.

Attempts to overcome the lack of vegetation along the shoreline of the tailrace and dredge cuts was futile. The magnitude of the water level fluctuations in the area is too severe to allow native vegetation to establish along the shoreline.

The results of attempts to establish a chinook salmon spawning run into the Fort Peck tailrace are not yet fully known. Fingerlings were first planted in the tailrace in 1983, and plants have been made annually since. Spawning chinook have not been documented in the area.

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## INTRODUCTION

The Fort Peck Fisheries Habitat Evaluation and Improvement Study was begun in the spring of 1985 and completed in the winter of 1989 with the submission of this report to the U.S. Army Corps of Engineers (COE), Missouri River Division (MRD), Omaha District. This study was designed to gather data on the fisheries below Fort Peck Dam, identify impacts of the operation of Fort Peck Dam on the fishery, and develop and test means of reducing or eliminating these impacts through a combination of water level management and habitat enhancement.

Fort Peck Dam is the upstream-most dam in a series of impoundments operated by the COE on the Missouri River. The COE develops, controls, maintains and conserves water resources in the Missouri River to fulfill authorized project purposes of flood control, water quality, navigation, power generation, recreation, and fish and wildlife conservation. In the past, fish and wildlife have received little consideration in the operation of the Fort Peck project. Within the constraints of available water, Fort Peck Dam has been operated to produce peaking power, resulting in large daily fluctuations in water levels below the dam. The impacts of water level fluctuations on fisheries below hydropower facilities are well documented (Hawke 1978, Reiser and White 1981, McMullin and Graham 1981, Fraley and Graham 1982, Becker et al 1982), and were shown to be occurring below Fort Peck (Frazer 1985). These problems, and a limited supply of quality habitat, have prevented the fishery below Fort Peck Dam from reaching its maximum potential.

Previous efforts by the Montana Department of Fish, Wildlife, and Parks (MDFWP) to improve the fishery below the dam could not overcome the effects of fluctuating water levels. The COE contracted with the MDFWP to investigate and minimize the impacts that were occuring. Frazer (1985) identified and preliminarily quantified the impacts of daily discharge fluctuations on the fishery and provided a foundation to initiate the Fort Peck Fisheries Habitat Evaluation and Improvement Study.

The COE has joined with the state in trying to identify and alleviate many of the fisheries problems below Fort Peck Dam. It funded a two-phased fisheries study through the DFWP beginning in 1985 to identify and evaluate the impacts of the current operation of the Fort Peck project on the downstream fishery, and to test methods of reducing or eliminating these impacts through improved water management and habitat enhancement. Objectives of the study were:

Phase 1- a) To gather baseline data on the fishery downstream from Fort Peck Dam, and on the impacts of water level fluctuations on the fishery, with major emphasis on the reproduction of rainbow trout, walleye, sauger, and forage fish.

b) To develop a better understanding of the stage-discharge relationship downstream from Fort Peck Dam.

c) To work with the COE to initiate changes in water management below Fort Peck Dam to benefit the fishery, and to evaluate the effectiveness of these changes.

d) To initiate habitat improvement work in selected areas below the dam, evaluate the effectiveness of these projects where possible, and to outline plans to continue evaluation in the second year of study.

e) To identify potential long term plans involving water level management and habitat modifications for improving the fishery potential of the downstream area.

Phase 2- a) To continue to work with the COE to develop a long term water management plan for Fort Peck that will provide maximum benefits for the downstream fishery and still be achievable within the other operational constraints of the project.

b) To expand habitat work and develop additional projects to provide as much quality rainbow trout and chinook salmon spawning and rearing habitat as practical in the study area, and to design these habitat projects to be usable over as wide a range of flow conditions as possible.

c) To identify major sediment sources and work with local Corps personnel to reduce or eliminate as much sediment input into the study area as possible.

d) To work with state fisheries personnel to implement and evaluate a stocking program below Fort Peck Dam for developing a good resident game fish population in the area.

e) To evaluate the possibilities of using flow control structures below Fort Peck Dam to help alleviate many of the fisheries and related water management problems, to assess the environmental consequences of this type of project, and to develop and initiate this type of project if it is found to be feasible.

This milestone summarizes the results of four field seasons of this study, and also uses pertinent data collected by Frazer

(1985). Actions to reduce negative impacts of fluctuating water levels on the fishery are recommended.

Progress has been made in adjusting the discharges at Fort Peck for the benefit of the downstream fishery. Since 1986, discharge patterns have been below the minimum levels recommended during this study, but generally above historic levels. A major rainbow trout habitat enhancement project was completed in the fall of 1985, and upgraded and expanded in the fall of 1987.

## DESCRIPTION OF STUDY AREA

The study area extends from Fort Peck Dam to the mouth of the Milk River about 10 miles downstream.

Fort Peck Dam is a large, earth-filled dam located at river mile 1772 on the Missouri River in northeast Montana. Completion of the dam in 1937 backed water 134 miles upstream to near Zortman, Montana. Four large penstock tubes withdraw water 220 feet below the top of the dam. Two penstocks are used for power generation and have a maximum discharge capacity of about 17,000 cfs. The generating capacity of the two powerhouses is 185 megawatts. The total discharge capacity of all four penstocks is 45,000 cfs. A separate spillway system located on a bay east of the main dam has a discharge capacity of 230,000 cfs.

Fort Peck Dam is operated as a combined base-load and power peaking plant. The amount of peaking depends on water availability and power demand. Fort Peck Dam has altered the natural temperature and flow of the Missouri River downstream.

### Habitat

The study area below the dam exhibits several habitat features (Figure 1). The tailrace area immediately below the dam consists of a shallow shelf of large boulders which drops off into a pool approximately 40 feet deep. Numerous large boulders and concrete pillars have been placed in the channel to dissipate energy from dam discharges. In the center of the channel the spaces between the boulders have filled with gravel and silt, but boulders along the edges are not silted in and provide fish cover and resting area. The banks just downstream of the dam have been riprapped, while those in the remainder of the study area are mostly steep sand and silt banks and are very unstable. The river bottom in the tailpool area consists of sand and silt. Most of the tailpool is less than 10 feet deep, and there are a number of shallow mud flats. There are two 30 to 40 foot deep holes within two miles below the dam. Nine-tenths of a mile below the dam the tailpool is split by two large islands. The main flow follows the west channel. Near the upstream end of Duck Island, the velocity in the

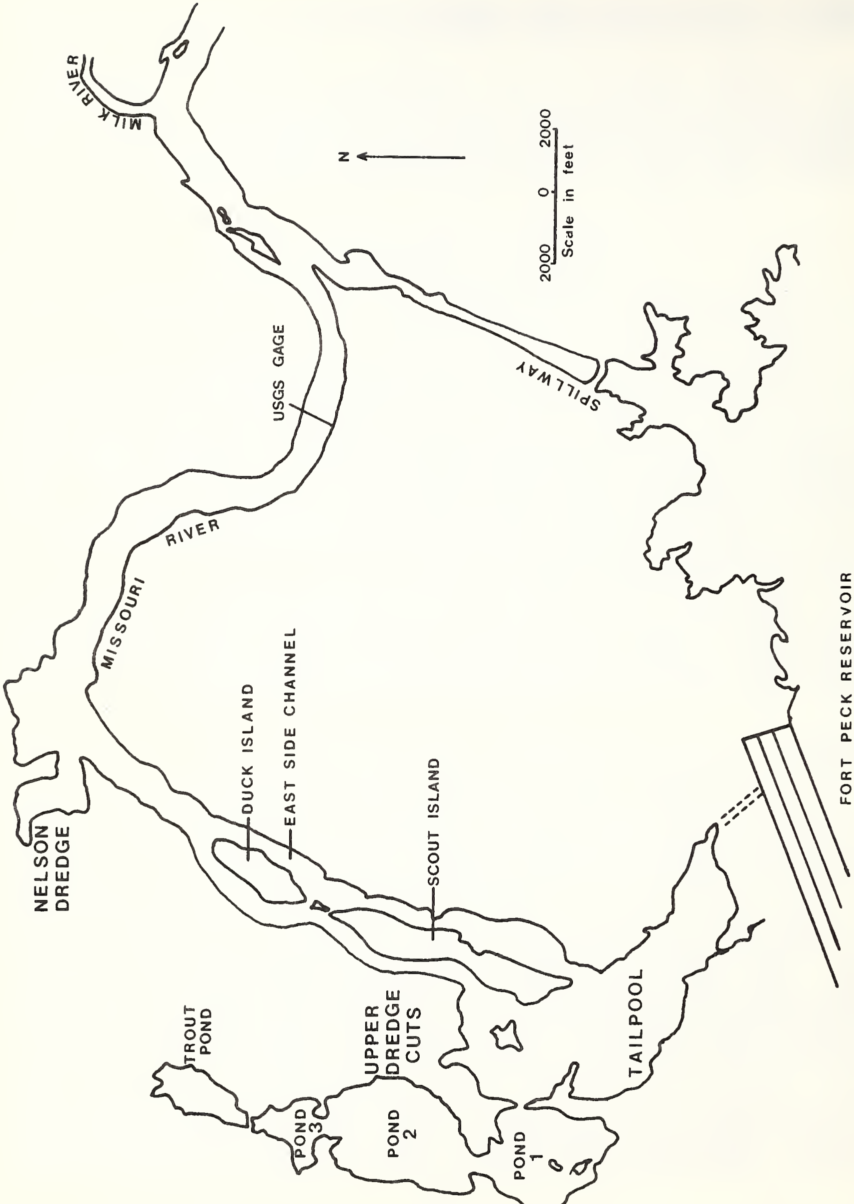


Figure 1. Map of the study area

west channel increases as the river passes through a narrow, rocky chute. Downstream, numerous gravel bars and small gravel points are interspersed with a sand and silt bottom.

The side channel east of Scout and Duck islands provides critical habitat for spawning, incubation, and rearing of rainbow trout. This channel is about 2 1/2 miles long, and passes about 1-10 percent of the water discharged from the dam. The substrate at the upper end of this channel is predominately sand and silt, with gravel and cobble becoming progressively more prevalent downstream. Two large riffle areas in the lower quarter mile of the channel provide the major spawning and rearing habitat for rainbow.

A unique habitat feature of the area is the dredge cut ponds, which were created by excavation to obtain fill during construction of the dam. They are connected directly to the main river, and their water levels are influenced by discharges from the dam.

There are two dredge cut areas. The upper one, about 1.6 miles downstream from the dam, consists of three interconnected ponds with a single connection to the river (Figure 1). The ponds have a total surface area of approximately 650 acres and a maximum depth of approximately 31 feet. Their average depth is 15 to 20 feet. The banks and bottom of the ponds are composed of sand and silt. The banks are steep and very unstable with little shoreline cover. Two gravel points provide potential spawning habitat for walleye and sauger.

The Nelson dredge cut, 6 miles downstream, consists of one 66 acre pond with a maximum depth of 28 feet. The mouth of Nelson dredge is larger than that of the upper dredge cuts, facilitating the exchange of water with the river. The main channel just downstream from Nelson dredge has been enlarged by dredging, creating a large bay. The bottom and banks in these areas are similar to those in the upper dredge cut.

## Fisheries

The variety of habitat found in the study area has resulted in a diverse fishery. Forty species of fish representing 14 families have been collected in the study area (Table 1). Several other species have been reported from the Missouri River or its tributaries between Fort Peck Reservoir, Montana and Garrison Reservoir, North Dakota (Brown 1971, Stewart 1982).

Table 1. Relative abundance of fish species found in the Fort Peck tailwaters and dredge cuts. (A) = abundant; (C) = common; (R) = rare.

| Family and Scientific Name | Common Name |
|---|---|
| ACIPENSERIDAE (Sturgeon family) | |
| Scaphirhynchus platorynchus | Shovelnose sturgeon (A) |
| Scaphirhynchus albus | Pallid sturgeon (R) |
| POLYODONTIDAE (Paddlefish family) | |
| Polyodon spathula | Paddlefish (A) |
| LEPISOSTEIDAE (Gar family) | |
| Lepisosteus platostomus | Shortnose gar (R) |
| HIODONTIDAE (Mooneye family) | |
| Hiodon alosoides | Goldeye (A) |
| SALMONIDAE (Trout family) | |
| Coregonus artedii[1] | Cisco (C) |
| Coregonus clupeaformis | Lake whitefish (R) |
| Salmo trutta | Brown trout (R) |
| Salvelinus namaycush | Lake trout (C) |
| Oncorynchus mykiss | Rainbow trout (C) |
| Oncorynchus tshawytscha[2] | Chinook salmon (R) |
| OSMERIDAE (Smelt family) | |
| Osmerus mordax | Rainbow smelt (R) |
| ESOCIDAE (Pike family) | |
| Esox lucius | Northern pike (C) |
| CYPRINIDAE (Minnow family) | |
| Phoxinus eos | Northern redbelly dace(R) |
| Cyprinus carpio | Carp (A) |
| Hybopsis gracilis | Flathead chub (R) |
| Couesius plumbeus | Lake chub (C) |
| Notropis atherinoides | Emerald shiner (C) |
| Notropis hudsonius[3] | Spottail shiner (C) |
| Hybognathus argyritis | Western silvery minnow(C) |
| Pimephales promelas | Fathead minnow (R) |
| Rhinichthyes cataractae | Longnose dace (R) |
| CATOSTOMIDAE (Sucker family) | |
| Carpoides carpio | River carpsucker (A) |
| Cycleptus elongatus | Blue sucker (C) |
| Ictiobus bubalus | Smallmouth buffalo (A) |
| Ictiobus cyprinellus | Bigmouth buffalo (A) |
| Moxostoma macrolepidotum | Shorthead redhorse (A) |
| Catostomus catostomus | Longnose sucker (A) |
| Catostumus commersoni | White sucker (A) |

Table 1. (Continued)

| Family and Scientific Name | Common Name |
|---|---|
| ICTALURIDAE (Catfish family) | |
| *Ictaluras melas* | Black bullhead (R) |
| *Ictaluras punctatus* | Channel catfish (C) |
| *Noturas flavus* | Stonecat (R) |
| GADIDAE (Codfish family) | |
| *Lota lota* | Burbot (C) |
| PERCICHTHYIDAE (Sea bass family) | |
| *Morone chrysops* | White bass (R) |
| CENTRARCHIDAE (Sunfish family) | |
| *Micropterus dolomieui* | Smallmouth bass (R) |
| *Pomoxis annularis* | White crappie (R) |
| PERCIDAE (Perch family) | |
| *Perca flavescens* | Yellow perch (C) |
| *Stizostedion canadense* | Sauger (C) |
| *Stizostedion vitreum* | Walleye (C) |
| SCIAENIDAE (Drum family) | |
| *Aplodinotus grunniens* | Freshwater drum (R) |

[1] First planted in Fort Peck Reservoir in 1983.
[2] First planted in study area in 1983.
[3] First planted in Fort Peck Reservoir in 1982.

Trophy-sized rainbow trout inhabit the study area and spawn successfully in the East Side Channel and in the main river. Rainbow spawning was first documented in 1979 (Stewart 1980), but local residents have reported catching rainbow in the area for many years. Both the study area and Garrison Reservoir, the next reservoir downstream, have been stocked with limited numbers of rainbow in the past. However, the actual origin of this rainbow population is unknown. These rainbow provide an important fishery that is unique to this part of eastern Montana. Sampling efforts and angler tag returns indicated that rainbow trout remain in the study area throughout the year.

Walleye and sauger are the most popular game fish in the study area. They are found throughout the area but appear to favor certain habitats. Most walleye and sauger in the area are migratory fish. Some walleye and sauger spawning does occur in the study area.

Northern pike, another popular game fish, are found predominantly in the dredge cuts. Pike spawn in the dredge cuts, but their success is limited by water level fluctuations and the resulting lack of shoreline vegetation.

A population of lake trout inhabits the tailpool area below the dam. These fish provide a limited fishery, especially in the spring and fall. They also move into the dredge cuts during the winter and are caught by ice fishermen. It is not known whether the lake trout spawn below Fort Peck Dam or whether the population depends entirely on recruitment from the reservoir.

Paddlefish also are present in the study area. In late June and early July 1978, their numbers were estimated at approximately 3,400 in the upper dredge cut, with another 500 thought to dwell in Nelson dredge (Needham 1979). Tag return data indicate these fish are part of a paddlefish population that inhabits Garrison Reservoir and migrates up the Missouri and Yellowstone rivers to spawn. Paddlefish in the study area apparently prefer the dredge cut areas, especially the upper one, but also use the tailpool on a seasonal basis. Sampling results indicate that part of the paddlefish population remains in the study area for extended periods. The dredge cuts appear vital to maintaining this paddlefish population.

Pallid sturgeon were found wintering in the deep holes in the tailrace during the winter of 1987-88, and, due to infrequent sightings in their historic range, became the focus of intense interest. Still photographs and underwater video films document their presence. A pallid was caught during seasonal gill netting in 1986. A general concern for the welfare of the species prompted the Dacotah Chapter of the Sierra Club to petition the U.S. Fish and Wildlife Service on June 16, 1988, to review the status of the pallid sturgeon and consider it for listing under the Federal

Threatened and Endangered Species Act. Their petition noted that there has been no documentation of pallid sturgeon reproduction by state, federal, or university biologists for over 15 years.

Chinook salmon were first planted below Fort Peck Dam in the spring of 1983. Annual plants have continued since that time, either as fry, or in the eyed egg stage. The first spawning run was anticipated below Fort Peck in the fall of 1986 but did not materialize. Neither eggs or fry were available for planting in the winter of 1988-89 because of a poor take from the spawning run at Garrison Reservoir. Other game fish found in the study area include channel catfish, burbot, shovelnose sturgeon, and an occasional brown trout.

## METHODS

Detailed descriptions of equipment and methods are in previous reports (Frazer 1985, 1986, 1987).

### Physical Measurements

The State of Montana's Wetted Perimeter (WETP) (Nelson 1984) method was used to develop minimum discharge recommendations for the East Side Channel. Current velocity measurements were made with a AA current meter and top set wading rod.

Changes in elevation of the tailpool and dredge cuts were measured using Stevens type F continuous recording water level recorders, staff gauges, and Daily Operating Records for the Fort Peck powerhouse.

Continuous reading 30 day thermographs were used to monitor water temperatures.

### Spawning Surveys and Egg Sampling

Rainbow redd counts were made weekly after the first redds were located each year. All major spawning areas were surveyed each week. All redds were either located on a map or marked with a painted stone to distinguish existing redds from "new" redds each count, and to determine the extent of superimposition. Weekly totals of new redds were added to attain total redd counts for each spawning area.

Measurements were made at a number of redds in 1985 to determine the approximate area of the redds and the depth and current velocity that spawners were selecting for. Length and width of each redd, water depth to gravel surface, and water depth to the center of the redd depression were measured. Velocity measurements were taken at the upstream end of each redd at 0.6 of the water depth.

A 40 x 40 inch, 750 micron nitex net was used to collect eggs from excavated rainbow redds. The net was placed immediately downstream of the redd, then a shovel was used to turn the gravel and free the eggs. The eggs were sorted and counted in the field and all live eggs were returned to the gravel.

The same nitex net and a 7 x 17 inch fine mesh dip net were used to sample for walleye and sauger eggs on a large gravel bar located eight miles below Fort Peck Dam. The nets were placed on the bottom and the area upstream was kicked or fanned to dislodge eggs. All samples were sorted and counted in the field.

Ten egg trays were set on two gravel points in the upper dredge cuts to collect walleye and sauger eggs. Trays were filled with rock substrate, placed at varying depths at each point and left for the entire spawning period. The trays and enclosed substrate were then examined for eggs at the end of the spawning period.

## Egg Bag and Emergence Trap Experiments

Rainbow eggs were collected, fertilized, and allowed to water harden before being placed in fiberglass screen bags and emergence traps. Egg bags were buried in the gravel to a depth of about 6 inches.

Emergence traps were built using a design described by Fraley, Gaub and Cavigli (1986). In 1986, the bottoms of five of these traps were enclosed with fiberglass screen. These traps were partially filled with gravel from the area where they would be planted, either in new or natural gravel, and 200 fertilized eggs were enclosed in each trap.

Unscreened emergence traps were placed at random over natural redds. The traps were checked periodically until the first fry was collected, then checked every other day.

In 1986, a wooden incubation box was built to act as a control chamber to evaluate rainbow egg mortality due to handling. The box contained five chambers and was designed to allow water to flow through it when placed in a stream. It was submerged in Duck Creek, a seep water stream below the dam with a constant flow of about 4 cfs. The first chamber of the box was filled with large gravel to dissipate flow through the box. Eight egg bags with 50 eggs in each were placed in the other four chambers. These bags were handled the same as bags buried in the artificial redds.

## Fish Measurements

All game fish and a representative sample of nongame fish collected during sampling were measured to the nearest 0.1 inch and weighed to the nearest 0.01 pound. Most adult rainbow trout collected were tagged with a numbered Floy anchor tag.

## Electrofishing

A 20-foot inboard jet boat was used for electrofishing from 1986-1988. Prior to that, an 18 foot outboard jetboat was used on the project. Each boat was equipped with boom mounted positive electrodes, a 240 volt gas generator, and a Coffelt VVP-10 voltage regulating unit. The hull of the aluminum boat acted as the negative. Pulsed DC current was used for sampling adult rainbow, but the pulse rate was increased to 200 pulses/second to approximate straight DC current. At times, straight DC current was used, but with little success. Most shocking was done at night.

These same boats, generator, and VVP were used with a hand held mobile positive electrode to sample young-of-the-year rainbow in the East Side Channel, and to sample forage fish along the dredge cuts shoreline.

Estimating the population of the rainbow below Fort Peck is not legitimate because of the relatively low number of fish marked and recaptured each year. In most years, 10 or fewer fish are recaptured, not enough to base an estimate on. If fish that were tagged in previous years, or in previous shocking runs the same year, are returning to or staying in the area, their susceptibility to recapture is low. Fish may be leaving the area and not returning after being shocked and tagged, and the possibility of differential mortality exists. Perhaps future attempts to capture spawning rainbow trout in the East Side Channel should utilize trap nets rather than electrofishing.

## Gill Netting

Gill nets were fished overnight in the upper and lower dredge cuts and in the tailpool area at locations established by Needham (1979) (Figure 2). Ten 125 x 6 foot experimental gill nets with five mesh sizes ranging from 3/4 to 2 1/2 inch square mesh, and four 100 x 8 foot 1/2 inch mesh monofilament nets were fished seasonally in the spring, summer, and fall.

## Seining

A 35 x 6 foot x 1/4 inch minnow seine was used to sample the dredge cuts shoreline areas wherever flooded vegetation could be found. It was worked by wading.


Figure 2. Location of standard experimental gill net sets, monofilament gill net set(s), and trap nets (+) in the Fort Peck tailrace and dredge cuts.

## Trap Netting

Two 4 x 6 foot frame trap nets constructed of 1 inch square mesh and having 50 foot leads were fished in the upper dredge cuts during the spring to sample for spawning walleye, sauger, and northern pike (Figure 2).

Frame traps measuring 3 x 4 foot with 1/4 inch square mesh netting were used to sample for forage fish and small game fish in the upper dredge cuts. One trap was fished for five days in the spring and two traps were fished for eight days in the fall.

## Habitat Enhancement

In the fall of 1985 and the fall of 1987, washed and graded gravel was purchased from a local gravel pit and delivered to the river bank in the East Side Channel. The 1985 gravel ranged from 3/4 to 2 1/2 inches in diameter, while the 1987 gravel ranged from 3/8 to 2 inches. A rubber tired front end loader was used to place the gravel in selected locations in the river channel while discharges were relatively low. High winter discharges from the dam were relied upon to distribute the gravel evenly through the area.

At these same times, fieldstone and boulders ranging from about 4 inches to about 48 inches were collected and transported from Bureau of Land Management land to the side channel. These were used to construct dikes in and around the gravel. Excess boulders were distributed randomly at the downstream end of one of the spawning areas.

Dead cottonwood trees were collected from along the riverbank, and tree trimmings from the parks and residential area of the town of Fort Peck were collected and hauled to the riverbank. Those larger than about 6 inches were notched, drilled with a 1/2 to 3/4 inch hole, and anchored in the river channel with rebar that had been cut into 4-6 foot lengths. The top several inches of rebar were bent over, against the anchored log, to prevent the log from coming free during high flows and being transported downstream. Trimmings narrower than 6 inches were anchored to logs, pilings, or larger fieldstone using cotton or sisal rope, or anchored to the riverbank by burying one end deep into the bank.

Christmas tree reefs were placed in the upper dredge cuts in coordination with two local sportsmans clubs. The Big Muddy Sportsmans Club placed several hundred trees in the west bay of pond 3 in 1985 and the Wolf Point Chapter of Walleyes Unlimited placed about 350 trees in the southwest bay of pond 1 in 1985. Big Muddy also prepared trees for placement in the southwest bay of pond 1 in 1988, but have not yet completed the project.

A gas powered water pump and fire hose with a high pressure nozzle were used in the spring of 1985 to loosen and flush sediment from spawning gravel in the East Side Channel.

## Substrate Sampling and Analyses

Substrate samples were collected using a bucket and shovel in 1986 and a hollow core sampler in 1988. Three samples of purchased spawning gravel were collected when the gravel was delivered in 1985, and four samples were collected from the channel in the fall of 1986 after being in the channel for approximately a year. Three samples of natural spawning substrate were collected from areas where spawning had been documented in the past. All 1986 samples were collected during low flows when sample sites were totally dewatered. In 1988, the hollow core sampler was used to collect four samples of natural gravel, two samples of gravel placed in 1985, and four samples of gravel placed in 1987.

Samples were separated by washing them through 63.5, 25.4, 12.7, 6.35, 2.0 and .074 mm sieves. Samples from the 6.35 mm and larger sieves were measured by volumetric displacement using techniques modified from McNeil and Ahnell (1964). Samples from the two smaller sieves were dried and weighed to avoid the large error associated with wet analysis of such small sizes (Shirazi and Seim 1979). In 1988, Imhoff cones were used to measure the volume of material suspended in the water inside the sampler and in the ambient river water. The river water contained undetectable amounts of settleable material.

To calculate dry weight, the volume of settled material in the cone was multiplied by an arbitrarily chosen conversion factor of 0.3. Shepard and Graham (1982) cited conversion factors ranging from 0.23 to 0.44. Shirazi and Seim (1979) calculated a factor of 0.33 for the geologic area they were working in, and Weaver (unpublished data) calculated a factor of 0.27 for the Flathead drainage in northwestern Montana.

Rock densities were calculated for each particle size for both new and natural gravel by dividing dry weight of material in grams by its displaced volume of water in cubic centimeters. These density values were then used to convert all volumes to dry weight for final analysis (Table 2).

Table 2. Calculated density values for gravel placed in the East Side Channel in 1985 and 1987 to enhance rainbow trout spawning.

| | Particle size in millimeters (inches) | | | |
|---|---|---|---|---|
| | >63.5(2 1/2) | 25.4(1.0) | 12.7(1/2) | 6.35(1/4) |
| 1985 | 2.67 | 2.80 | 2.57 | 2.38 |
| 1987 | 2.62 | 2.63 | 2.56 | 2.50 |

## RESULTS AND DISCUSSION

Fort Peck Dam historically has been operated for peaking power production. Discharges have been maintained at high levels during the day, then dropped at night, resulting in large daily water level fluctuations below the dam (Appendix Figure 1). This pattern was typical of historic water level fluctuations occurring below Fort Peck Dam, and had two major impacts on the downstream fishery: 1) Fluctuating water levels in the river severely inhibited rainbow trout spawning and rearing success. 2) Daily water level fluctuations in the tailpool and dredge cuts caused a fluctuation zone along the shoreline where shoreline or rooted aquatic vegetation could not become established. Forage and gamefish in the area need vegetation for spawning and security cover. Erosion of shorelines in the tailpool and dredge cuts and the viability of the limited amount of trout spawning and rearing habitat available below the dam were intensified by these fluctuations.

One of the purposes of this study was to work with the COE to develop an improved discharge plan for Fort Peck Dam that would recognize fisheries values. Improved water level management could then be combined with habitat improvement to try to overcome some of the major problems affecting the downstream fishery. Progress was made in both areas, however, a permanent solution to the problem has not yet been achieved.

## Rainbow Trout

### Water Level Management

Analysis of WETP data collected in 1984 and 1986 suggests that a minimum instantaneous (24 hours/day) discharge of 7,800 cfs is necessary from Fort Peck Dam to maintain acceptable spawning and rearing conditions for salmonids in the East Side Channel below Fort Peck Dam. A minimum instantaneous discharge of 7,800 cfs will maintain 250 cfs in the East Side Channel. This discharge should be held from April 1 through September 30 to insure that spawning, egg incubation, and fry emergence are completed, and that fry rear to sizes that allow them to adjust to daily water level fluctuations.

In 1985, the DFWP preliminarily recommended to the COE a minimum instantaneous discharge of 6,700 cfs with an absolute minimum instantaneous discharge of 4,500 cfs, from April 1 through September 30.

A minimum instantaneous discharge of 4,500 cfs is still considered to be the absolute minimum acceptable for rainbow trout spawning and rearing below Fort Peck Dam. This recommendation is based on field observation of key spawning areas during periods of low discharge. A discharge of 4,500 cfs maintains a flow of only about 60 cfs in the East Side Channel. MDFWP also recommends a minimum discharge of 2,700 cfs from October 1 through March 31. The recommendations made for rainbow are also expected to benefit other fish species throughout the study area.

### Redd Counts

Rainbow trout redds have been counted throughout the study area each year from 1983 through 1988 (Table 3). An explanation of the lower count in 1983 has been detailed in Frazer (1986).

Table 3. Total number of rainbow trout redds counted below Fort Peck Dam, 1983-88. The number of redds constructed in the 'new' gravel is in parenthesis.

| Year | Total # redds |
|---|---|
| 1988 | 788 (289) |
| 1987 | 398 (108) |
| 1986 | 263 (91) |
| 1985 | 291 |
| 1984 | 246 |
| 1983 | 187 |

Rainbow select the same spawning areas each year, but the distribution of redds within each area varies. In the past, strong current velocities associated with higher minimum daily discharges during the spawning season forced spawning fish out of the center of the channel. Frazer (1986) suspected that current velocity was the determining factor for rainbow redd location. Spawning was concentrated in a few isolated areas of marginal habitat in shallow shoreline areas. This caused several problems. A majority of redds were susceptible to dewatering if discharge levels decreased at any time before emergence. Concentrating all spawning in a few isolated areas resulted in significant superimposition of redds. This caused high mortality of the extremely sensitive incubating eggs.

The habitat work completed in 1985 and 1987 was designed to overcome these problems by providing as much usable habitat as possible under the range of anticipated flows. Subsequent redd counts indicate it was successful. Although there were some areas of concentration where superimposition did occur, this problem was much less severe than prior to placement of the gravels in the channel.

The majority of the 1987 gravel was placed immediately upstream of a natural riffle selected by the rainbow for spawning. The work was completed in mid November when discharges from the dam were about 2,000 cfs during the day. Current velocity in the spring was lower than anticipated at that location. Daily maximum discharges approached 12,000 cfs, but were usually around 7,000-8,000 cfs. Daily minimum discharges, as low as 3,800-4,000 cfs, occurred during the late evening through early morning hours, the same time that most spawning probably occurred. As a result, rainbow did not favor this area for spawning in 1988. Less than 10 redds were built in this gravel in 1988.

## Incubation

Incubation success was evaluated by excavating redds and with egg bag plants to compare survival between natural spawning habitat and spawning gravel placed during this study (Table 4). It is obvious that the addition of spawning gravel to the East Side Channel has not only increased the amount of spawning area available to rainbow, but the overall survival of the eggs has been dramatically improved since 1984. The 1985 data are of limited value because of the small number of eggs and sac fry collected that year. Among the 1988 samples, the survival rate in redds built in the gravel placed in 1985 was 70.3 percent, while that in the gravel placed in 1987 was 63.7 percent. Some of the gravel purchased in 1987 was used to replace 1985 gravel that had become excessively sediment-laden. Spawning activity was undeterred at those locations.

Table 4. Percent survival of incubating rainbow trout eggs in the East Side Channel of the Missouri River near Fort Peck, Montana, 1984-88.

| Year | Natural Gravel | New Gravel | Overall Survival |
|---|---|---|---|
| 1988 | 68.4 | 69.7 | 69.1 |
| 1987 | 59.1 | 41.8 | 50.1 |
| 1986 | 34.4 | 51.2 | 44.1 |
| 1985 | 40.0 | -- | 40.0 |
| 1984 | 34.6 | -- | 34.6 |

Table 5 presents results of artificial egg bag experiments conducted in 1986. Half of the egg bags planted in natural gravel areas were subjected to severe dewatering before the first sampling date. These bags were planted in an area where spawning had occurred that year. Minimum daily discharges were about 4,000 cfs at the time. All eggs in the dewatered bags were dead when first checked, so they are not included in Table 5.
On the first sampling date, survival in the bags in the new gravel was greater than 99 percent, compared to 60 percent in bags in the natural gravel areas. Survival rates in the control bags showed that handling mortality was not a problem. Nearly two weeks later, when the remaining three bags were pulled from the natural gravel, only 9 percent of these eggs were still alive. On the same date, 72 percent of the eggs in bags in the new gravel were still alive. By June 23, when the last bags were removed from the new gravel, survival was almost 57 percent, and the hatch rate was over 94 percent complete.

## Emergence

Emergence traps were placed over redds to capture fry as they emerged from the gravel. So few fry were captured using this method that no conclusions can be drawn regarding survival to emergence.

Table 6 shows the results of experiments conducted in 1986 using enclosed emergence traps. Several problems experienced during the study limit the value of the results, but the data suggests that a higher percentage of fry successfully hatched in the new gravel. The traps which temporarily lost capture bottles showed the lowest total return of fry, indicating that some fry probably escaped while the bottles were missing. Any live eggs still in the traps are not included in the return estimates. When the enclosed traps were placed in the stream, turbidity was extremely high due to recent rains. Some eggs may have been damaged by gravel moving in the traps while they were being set out. Other eggs may have settled on top of the gravel in the traps and been washed away as current velocities increased. When the traps were pulled on July 18 there were few remnants of dead eggs left inside. It appeared that all mortality occurred early, probably as the traps were put out. Although the traps did accumulate algae and sediment, the fry that did survive were in excellent condition, and there were no recently killed eggs or sac fry present to indicate that suffocation was occurring.

Data from the emergence trap and egg bag experiments were coupled with temperature data collected in the side channel to develop Table 7. Values determined in this study were similar to those reported for rainbow trout by Embody (1934).

Table 5. Survival of rainbow trout eggs in fiberglass screen bags planted in the East Side Channel and in a control chamber in 1986. All plants were completed on May 9.

| Date | Habitat | No. Eggs Sampled | Percent Survival | Percent Hatched |
|---|---|---|---|---|
| 5/21 | Natural Gravel | 50 | 60.0 | 0 |
| | New Gravel | 156 | 99.4 | 0 |
| | Control | 117 | 95.7 | 0 |
| 6/2 | Natural Gravel | 146 | 8.9 | 0 |
| | New Gravel | 221 | 72.2 | 0 |
| | Control | 40 | 80.0 | 0 |
| 6/10 | New Gravel | 99 | 58.9 | 22.4 |
| | Control | 104 | 61.5 | 0 |
| 6/16 | New Gravel | 83 | 45.8 | 86.9 |
| | Control | 42 | 73.8 | 35.5 |
| 6/23 | New Gravel | 95 | 56.8 | 94.4 |

Table 6. Percent return of 200 eggs enclosed in emergence traps and anchored into spawning areas in the East Side Channel in 1986. Three traps were placed in the new gravel and two in the natural gravel.

| Habitat Area | June 27 | June 30 | July 3 | July 8 | July 14 | July 18 | Total Catch | Percent Return |
|---|---|---|---|---|---|---|---|---|
| New Gravel | - | 10 | 15 | 13 | 4 | 9 | 51 | 25.5 |
| | - | - | - | * | - | 2 | 2 | 1.0 |
| | - | - | 13 | 10 | - | 14 | 37 | 18.5 |
| Natural Gravel | 4 | 5 | 4 | 4 | - | 2 | 19 | 9.5 |
| | 3 | 2 | 2 | - | * | 1 | 8 | 4.0 |

* Capture bottles were missing on these days, so any fry that emerged between this date and the previous date were lost to the results of the experiment.

Table 7. Comparison of Fahrenheit temperature units to various stages of development of rainbow trout in the East Side Channel in 1986. One Fahrenheit temperature unit equals $1^{\circ}F$ above $32^{\circ}F$ for a 24 hour period.

| | 80% Eyed | Hatched 22% | Hatched 94% | Emerged from Gravel 6% | Emerged from Gravel 87% |
|---|---|---|---|---|---|
| Temp. Units | 379 | 589 | 822 | 902 | 1,323 |
| Days | 21 | 32 | 45 | 49 | 70 |

Table 8 presents estimates of timing to various stages of rainbow egg development below Fort Peck Dam. The estimates were made on the assumption that spawning begins April 1 and peaks May 1. These dates were selected based on redd count data. The dates reported in Table 8 were calculated using accumulated temperature units based on 1986 temperature data. They will vary depending on spring weather conditions and discharge patterns, but can be used to help identify critical rainbow development stages when attempting to regulate discharges during low water years.

Table 8. Estimated dates for various stages of development of rainbow trout in the East Side Channel.

| Stage of Development | Spawning Date | |
|---|---|---|
| | April 1 | May 1 |
| First Eye-up | April 28 | May 18 |
| 100% Eye-up | May 14 | May 31 |
| First Hatch | May 16 | May 31 |
| 100% Hatch | June 3 | June 19 |
| First Emergence | June 5 | June 22 |
| 100% Emergence | July 1 | July 15 |

During early stages of incubation, salmonid eggs can tolerate some dewatering as long as the gravel remains damp and air temperatures do not drop low enough to freeze the eggs. Reiser and White (1981) reported that incubating eggs from steelhead and spring chinook salmon were able to tolerate long periods of dewatering if the gravel remained damp. Hawke (1978) found high survival of pre-eyed and eyed eggs that were stranded up to three weeks in damp gravel. But both studies reported that alevins were much less tolerant of dewatering than eggs. Becker, Neitzel and Fickelsen (1982) reported that the demand for dissolved oxygen by chinook salmon was greatest immediately before hatching. They also found that chinook eggs could tolerate dewatering better than alevins. A number of the dead rainbow eggs collected below Fort Peck Dam during redd sampling in 1984 appeared to have died just at hatching (Frazer 1985), indicating they had died from oxygen stress during this critical period. Over 37 percent of the sac fry collected from redds in 1984 were also dead, indicating that even many of the eggs that hatched successfully were not able to tolerate the periodic dewatering that was occurring.

Numerous studies have shown that even partial dewatering of salmonid eggs can cause severe stress, resulting in high egg mortality, delayed hatching and the production of small, weak sac fry (Corning 1955, Silver, Warren and Doudoroff 1963, Shumway, Warren and Doudoroff 1964, Becker, Neitzel and Fickelsen 1982). To provide a consistently viable fishery at Fort Peck, every effort must be made to maintain minimum discharges at sufficient levels to prevent dewatering once spawning has begun. If discharges must be reduced in years of extremely low water to maintain priority water levels for the reservoir fisheries, plans should be made to maintain minimum discharges at least during the critical hatching and pre-emergence stages. Based on Table 8, this would be from mid May through early July. Alternatively, discharge levels during rainbow spawning should be held low enough to prevent spawning in areas which may later become dewatered, yet be high enough to allow spawners access to sufficient amounts of gravel to successfully complete spawning.

## Rearing

Insufficient quantities of rearing cover appeared to be a factor limiting recruitment to the rainbow population below Fort Peck Dam. The East Side Channel is the only known rearing area for young-of-the-year (YOY) rainbow. This area contained little natural instream structure to provide rearing habitat, so YOY rainbow relied heavily on filamentous algae to provide the necessary rearing cover. Gardner and Berg (1983) found similar conditions in the Marias River downstream from Tiber Dam. They found that YOY rainbow rearing downstream from Tiber Dam were dependent on mats of filamentous algae, and that the availability of this algae was a major factor limiting the distribution of these fish. Past work has shown that fluctuating water levels can have a significant impact on the amount of algae below Fort Peck Dam (Frazer 1985). Low minimum daily discharges have resulted in almost total elimination of algae from the side channel. This was an important consideration in the DFWP's minimum discharge recommendations to the COE.

Even when algae is abundant, it alone does not provide enough cover for small rainbow to remain in the open channel during higher discharges. Past sampling of YOY rainbow has shown that they migrate daily with changing water levels in an attempt to avoid high current velocities. This is very energy expensive. As the fish move into shallow shoreline areas, they risk being stranded if water levels suddenly drop. Stranding has been documented in the East Side Channel (Frazer 1987). By reducing the lateral migrations of YOY rainbow, energy can be directed toward growth rather than spent adjusting to fluctuating discharges.

Improvements in the discharge regime from Fort Peck Dam and the addition of spawning gravel and rearing cover have lead to an increase in the abundance of YOY rainbow in the East Side Channel (Figure 3). Placement of rock dikes, logs, and tree limbs not only provided additional cover, but also a diversity of cover types. The channel now mimics a "natural" trout stream where trees along the bank are periodically recruited into the stream channel and used for cover. Introduced cover materials were located in areas of the channel that are not subject to intense dewatering, but also where they will serve as current velocity barriers during periods of high discharge. Though CPUE data was not kept, it is thought that the lower number of YOY captured in 1987 and 1988 was due to reduced effort.

Discharges during the spring and summer of 1983 were fairly representative of those historically occuring at Fort Peck. Work on downstream projects necessitated an increase in the power demand at Fort Peck in 1985, resulting in discharge levels that were higher than the MDFWP absolute minimum recommendations (4,500 cfs) that year. Figure 4 compares historic (1983) and favorable (1985) minimum discharge regimes below Fort Peck Dam during the critical periods of the year. Nineteen eighty-five was the most favorable water year from 1983 through 1988 (Appendix Figure 1).

Electrofishing for YOY was conducted during daylight hours when water levels were rising, and prior to 1986, most YOY rainbow were captured along the stream margins, indicating that they were migrating laterally to maintain their position in areas of favorable current velocity. Discharges in 1986 met the absolute minimum recommendations only 22 percent of the time, but the additional spawning and rearing habitat introduced into the area in 1985 was sufficient to overcome the deficiency. Of the 364 YOY rainbow sampled in 1986 in the East Side Channel, 206 were collected from in and around the rock dikes built in the fall of 1985.

Discharges in the fall of 1986 unexpectedly dropped to zero during the early morning hours of September 18, and continued to do so through September 23. This discharge pattern dewatered the area of the side channel where most YOY rainbow were rearing. A minimum discharge of 1,800 cfs was then implemented. Most YOY rainbow were probably stranded and died, or evacuated the area, the first night of zero flow. At that time, the MDFWP recommendations for minimum discharge ended on September 15. It has since been extended to September 30. MDFWP now also recommends a minimum discharge of 2,700 cfs from October 1 through March 31.

Frazer (1987) found YOY rainbow that reared among the dikes to be 0.5 inches longer than those rearing in the algae and along the stream margin. In late July 1988, 37 of 38 YOY were

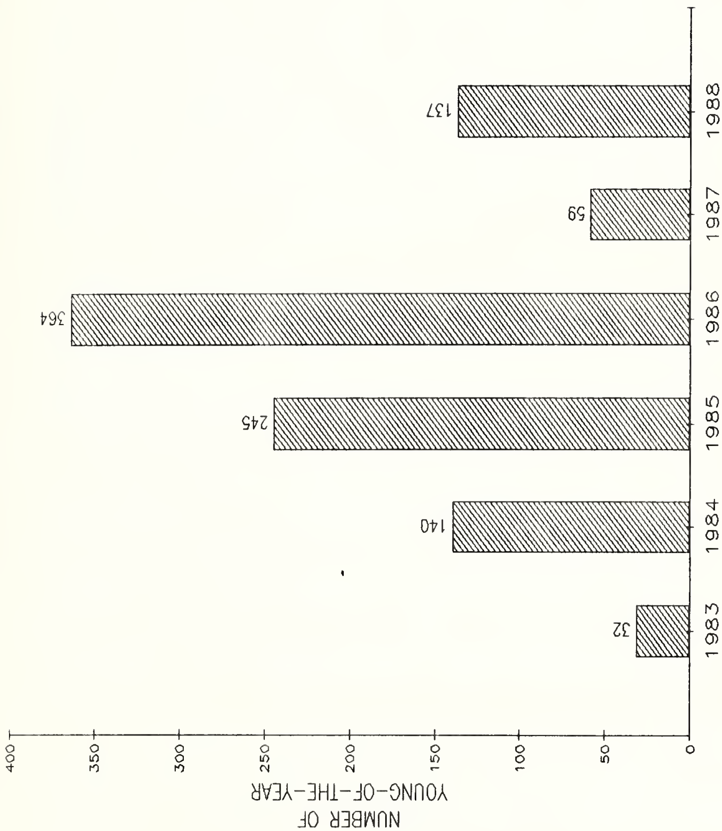


Figure 3. Total number of young-of-the-year rainbow trout captured by electrofishing in the East Side Channel, 1983-1988.

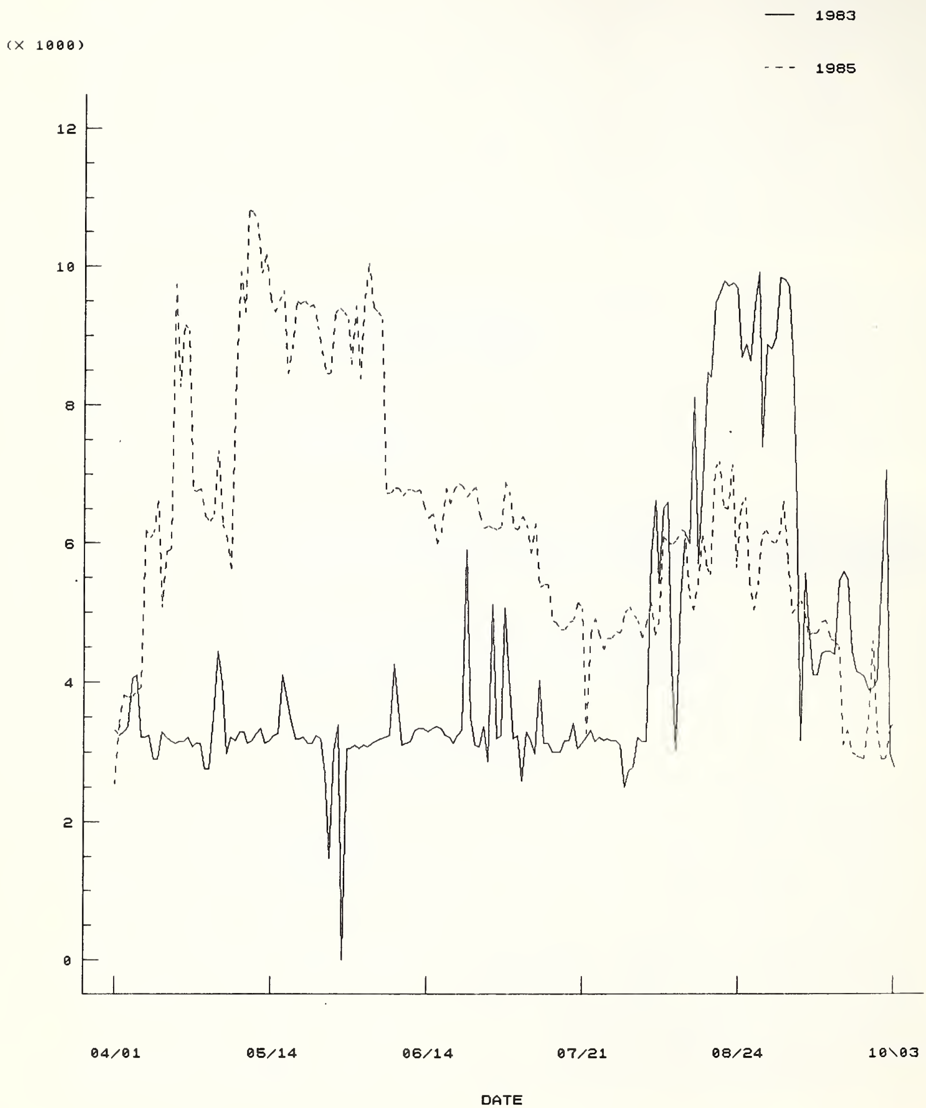


Figure 4. Representative patterns of minimum discharge at Fort Peck in an historic (1983) and a favorable (1985) year.

collected from among the dikes. About five or six fish along the stream margin were too small to be dip netted, and were not identified, but were initially thought to be rainbow. Sampling for YOY occurred in September in 1987. The average length of rainbow captured among and between the dikes was 2.7 inches (n=43), and the average for those caught in all other areas was 2.1 inches (n=22). August 1988 sampling yielded 51 YOY from along the stream margin, and only 8 from among the dikes and boulders. The average length of those along the stream margin was 1.8 inches, while those among the dikes averaged 2.2 inches.

Size variation in YOY rainbow can be explained two ways. The first is that earlier hatching fry will obviously begin growing sooner than later hatching fry, and thus attain larger size by any particular date. Secondly, the earlier hatching fry will occupy the most favorable rearing areas, leaving the marginal and poor rearing areas for the later hatching fry. The fry occupying the favorable rearing areas will spend less energy avoiding predators, migrating with changing water levels, and feeding. A higher percentage of their energy will be directed toward growth. Also, the food items selected by the fry in favorable rearing areas will probably be larger and yield a higher return for the energy spent capturing it.

## Substrate Analyses

Clean water released from Fort Peck Dam is highly erosive on the unstable, vertical banks downstream. Erosion is greatest during periods of high discharge which are common during winter months. Bare shale hills behind the powerhouse are also highly erosive. Snowmelt and heavy rains transport large amounts of sediment from these hills into the upper end of the side channel.

The 1985 gravel, when purchased, contained less than 2 percent by weight of substrate less than 12.7 mm (1/2 inch) in diameter. The samples of 1985 gravel collected in 1986 contained more than 16 percent substrate less than 12.7 mm, most of which was less than 2 mm in diameter (Frazer 1987). The gravel purchased in 1987 was composed of 25 percent 9.5 mm (3/8 inch) diameter gravel and 75 percent 50.8 mm (2 inch) diameter gravel. Generally, materials less than 6.35 mm (1/4 inch) in diameter are considered to adversely effect the suitability of gravel for successful salmonid spawning. In this report, materials less than 6.35 mm are classified as "fines".

The samples of 1985 gravel collected in 1988 showed results similar to those obtained by Frazer (1987). The 1987 gravel showed large increases in the amount of fines (Figure 5). Gravel placed in areas where current velocity was relatively high accumulated less fine material than gravel placed in areas of lower velocity. Gravel placed in 1985 and sampled in 1988 exhibited the same phenomenon (Appendix Table 1).

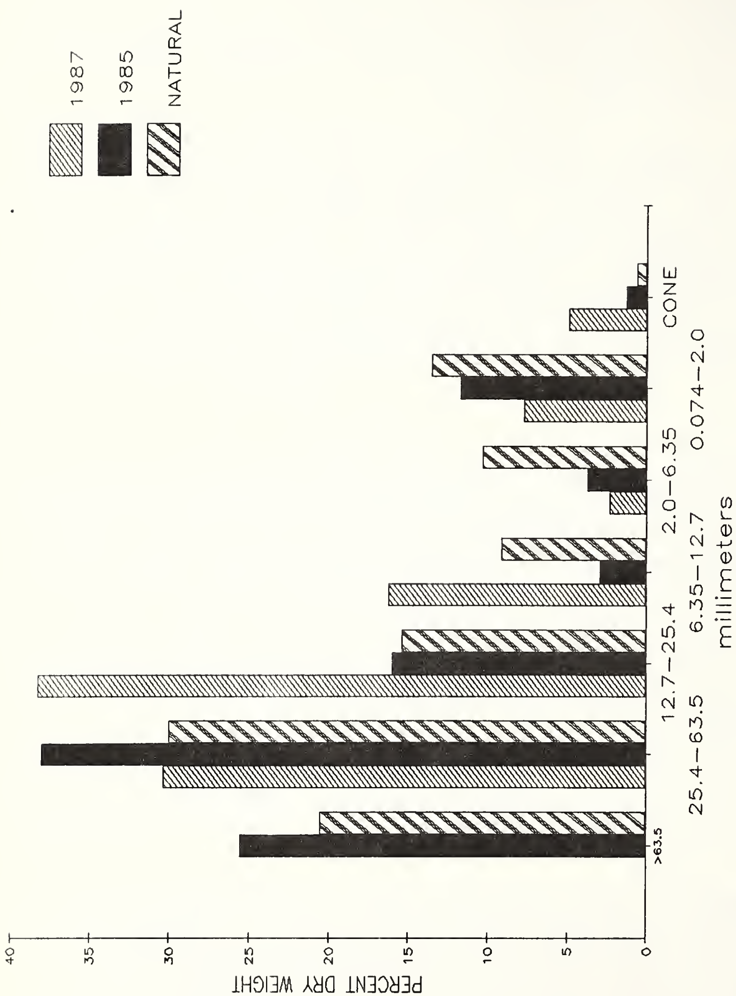


Figure 5. Composite substrate composition (by dry weight) of gravel collected from the rainbow trout spawning areas in the East Side Channel.

The adverse effects of fine substrate on salmonid embryo and fry survival have been well documented. Fine sediments fill interstitial spaces reducing gravel permeability, apparent velocity and dissolved oxygen. This in turn creates stress resulting in premature fry emergence and reduced fry length. It also traps larvae trying to emerge (Coble 1961, Cordone and Kelley 1961, Peters 1962, Koski 1965, Witzel and MacCrimmon 1981, 1983). The accumulation of fines in the natural gravel of the side channel has already resulted in serious compaction of much of this gravel making it unusable for spawning.

The rapid deposition of sediment in the upper end of the side channel and the significant increase in fine substrate in the new spawning gravel in one year are evidence of the severity of the sedimentation problem below Fort Peck Dam. This will be a major factor affecting the long term success of the habitat enhancement in the side channel. The accumulation of sediment near the upper end of the side channel is affecting the amount of water that passes down the channel. If deposition continues unchecked, the side channel could become effectively blocked, eliminating flow to the major rainbow spawning and rearing areas. The continued accumulation of sediment in the new spawning gravel will affect future egg survival, and the gravel eventually may become unusable.

The COE has identified the major sources of sediment input to the side channel. Plans have been made to construct check dams in the coulees that carry the significant portion of the sediment to the side channel, but funding shortfalls within the COE have prevented the implementation of these plans.

Dredging was considered for removing the accumulated sediment at the head of the side channel, but the logistics of accessing the area with the necessary equipment, such as draglines, made the project infeasible. Prevention of further sediment intrusion into the channel may eliminate the need for removal of the silt deltas that have formed at the mouths of major coulees. Lack of additional sediment to these deltas will probably prevent them from growing any larger, and they may become vegetated and stabilize.

## Walleye and Sauger

### Abundance

Table 9 lists the numbers and mean size of walleye and sauger captured during seasonal gill netting below Fort Peck Dam since 1979. More walleye have consistently been captured in the spring each year, indicating that they move into the area at that time of year, most likely for spawning. Sauger numbers show no particular trend.

Table 9. Number, average length, and average weight of walleye and sauger caught during seasonal gillnetting in the Fort Peck dredge cuts and tailrace, 1979-88.

| | | Spring | | | Summer | | | Fall | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | n | L | W | n | L | W | n | L | W |
| 1988 | we | 13 | 17.7 | 1.9 | 3 | 16.3 | 2.0 | 5 | 14.8 | 1.4 |
| | sgr | 9 | 17.7 | 1.6 | 16 | 14.8 | 1.0 | 8 | 15.4 | 1.1 |
| 1987 | we | 10 | 16.6 | 1.5 | 3 | 12.3 | 0.8 | 6 | 16.6 | 1.9 |
| | sgr | 13 | 16.2 | 1.4 | 12 | 14.3 | 0.9 | 29 | 16.6 | 1.3 |
| 1986 | we | 6 | 17.2 | 2.1 | 1 | 18.6 | 1.9 | 2 | 15.0 | 1.5 |
| | sgr | 12 | 16.5 | 1.3 | 6 | 16.7 | 1.4 | 8 | 16.6 | 1.5 |
| 1985 | we | 10 | 17.4 | 1.9 | 6 | 14.0 | 0.8 | 8 | 17.3 | 1.8 |
| | sgr | 21 | 16.4 | 1.5 | 41 | 14.4 | 1.2 | 40 | 16.0 | 1.3 |
| 1984 | we | 10 | 17.3 | 1.6 | 8 | 13.6 | 0.9 | 4 | 14.1 | 0.9 |
| | sgr | 29 | 13.4 | 0.6 | 14 | 12.6 | 0.5 | 44 | 14.0 | 0.9 |
| 1983 | we | 11 | 17.9 | 2.1 | 8 | 17.2 | 1.6 | 4 | 16.7 | 1.4 |
| | sgr | 1 | 18.7 | 1.8 | 12 | 14.3 | 0.9 | 18 | 14.1 | 0.9 |
| 1982 | we | - | - | - | 7 | 18.3 | 1.8 | - | - | - |
| | sgr | - | - | - | 9 | 16.1 | 1.1 | - | - | - |
| 1981 | we | - | - | - | 9 | 17.4 | 1.9 | - | - | - |
| | sgr | - | - | - | 47 | 15.0 | 0.9 | - | - | - |
| 1980 | we | - | - | - | 27 | 16.8 | 1.8 | - | - | - |
| | sgr | - | - | - | 67 | 14.7 | 1.0 | - | - | - |
| 1979 | we | - | - | - | 8 | 16.4 | 1.5 | - | - | - |
| | sgr | - | - | - | 7 | 15.3 | 1.0 | - | - | - |

Spring trap netting at two points in the dredge cuts has shown low numbers of walleye every year, and low numbers of sauger in 1987 and 1988 (Table 10). Traps were fished for about 10 days in 1984 and 1987, and for about 2 1/2 - 3 weeks other years. The low numbers of walleye may indicate that they do not prefer these points for spawning, or that they do not migrate far enough up river during years of adequate flow to access the dredge cuts for spawning.

Table 10. Number, average length, average weight, and spawning condition of walleye and sauger captured during spring trap netting in the Fort Peck dredge cuts, 1984-88.

| | | | | | male | | female | | |
|---|---|---|---|---|---|---|---|---|---|
| | | n | L | W | Rp | Sp | Gr | Rp | Sp |
| 1988 | we | 1 | 23.0 | 3.9 | - | - | - | - | - |
| | sgr | 9 | 16.3 | 1.4 | - | - | - | - | - |
| 1987 | we | 2 | 19.5 | 3.1 | - | - | 2 | - | - |
| | sgr | 3 | 15.9 | 1.4 | - | - | - | - | 2 |
| 1986 | we | 1 | 19.7 | 2.7 | - | - | 1 | - | - |
| | sgr | 64 | 15.0 | 1.3 | 29 | - | 20 | - | 3 |
| 1985 | we | 0 | - | - | - | - | - | - | - |
| | sgr | 15 | 14.9 | 1.0 | 9 | - | 4 | - | 2 |
| 1984 | we | 3 | 17.9 | 2.5 | 1 | - | 2 | - | - |
| | sgr | 25 | 14.2 | 0.8 | 19 | - | 3 | - | 1 |

The low spring water levels and the corresponding poor forage fish populations in the dredge cuts in 1987 and 1988 partially explain the absence of sauger in those years.

## Spawning

The walleye and sauger fishery below Fort Peck Dam is believed to consist predominately of fish that migrate into the area in conjunction with spawning migrations from Garrison Reservoir. The number of walleye and sauger migrating up the Missouri River apparently is affected by spring flow regimes. Stewart (1983) saw an abundance of walleye and sauger in the Missouri River in 1982 between the mouth of the Milk River and the North Dakota border. He related this to high spring flows that year in the tributary streams of the Missouri. In the spring of 1986, the Milk River and many of the downstream tributaries flooded at the same time that very low discharges were occurring at Fort Peck. A similar situation occurred in 1987 (Table 11), though not in 1988. Apparently, the migrating walleye and sauger that reached the study area in 1986 and 1987 were attracted by the large volume of warm water discharging from the Milk. Anglers reported catching large numbers of walleye in the Milk River in 1986 and in the Missouri River in the vicinity of the Milk in 1988. The presence of walleye in the area during apparently poor discharge conditions in 1988 is puzzling. In 1986-1988, neither walleye nor sauger spawning occurred at a gravel bar just upstream from the Milk where it occurs during more favorable years. Angler success on walleye and sauger is not known for spring 1987.

Table 11. Number of walleye and sauger captured during spring electrofishing relative to various flow conditions in the Missouri River below Fort Peck Dam and in the Milk River near it's mouth, 1983-88.

| | | no. fish captured | no. days F.P.avg discharge exceed 4,500 cfs in Mar,Apr,May (%) | smallest daily max discharge from F.P. Dam (cfs) | peak Milk R. discharge in April & May (cfs) | |
|---|---|---|---|---|---|---|
| 1988 | we | 0 | | | | |
| | sgr | 0 | 46 (50) | 5,880 | 656 | May 11 |
| 1987 | we | 0 | | | | |
| | sgr | 0 | 0 (0) | 5,544 | 4,640 | April 4 |
| 1986 | we | 2 | | | | |
| | sgr | 0 | 12 (14) | 6,264 | 6,750 | May 18 |
| 1985 | we | 75 | | | | |
| | sgr | 13 | 55 (60) | 10,728 | 137 | April 5 |
| 1984 | we | 22 | | | | |
| | sgr | 4 | 26 (29) | 7,176 | 143 | April 7 |
| 1983 | we | 21 | | | | |
| | sgr | 5 | 0 (0) | 7,632 | 1,950 | May 19 |

Walleye and sauger spawning in the study area was documented in only one year of this study, 1985 (Table 11). In that year, 75 walleye and 13 sauger in spawning condition were captured by electrofishing and incubating eggs were readily located during sampling. Previous work conducted by MDFWP documents spawning runs in 1983 and 1984 (Frazer 1985). The absence of spawning in recent years is intuitively related to the lower spring discharges, on average, from Fort Peck (Appendix Figures 2 and 3). Statistically relating the magnitude of the spawning runs to the discharges from Fort Peck is difficult due to the small sample sizes of fish, but various flow conditions are generally related to the presence or absence of spawners (Table 12).

## Population Enhancement

Previous studies have indicated that a lack of forage was one of the major factors preventing the development of a resident walleye or sauger population below Fort Peck Dam (Frazer 1985). When the forage base improved in 1986 due to the introduction of forage species from through the dam, the DFWP capitalized on the situation by planting approximately 1500 walleye fingerlings in the upper dredge cuts. The fish were raised in a nearby rearing pond, then trapped and transplanted to the dredge cuts in late September. They averaged approximately 3.2 inches long, and each was marked by fin-clipping before release. Subsequent evaluation of the contribution of these planted fish to the walleye fishery below Fort Peck has been discouraging. The poor return of walleye to the area limits the opportunity for evaluation, but of those fish captured during sampling, none have lacked a fin or exhibited obvious fin regrowth. Any of the planted walleye that survived probably emigrated due to poor forage conditions in the tailrace and dredge cuts in subsequent years.

## Habitat Enhancement

The major habitat improvement in the study area that may have been expected to benefit walleye and sauger was the addition of Christmas tree reefs to the dredge cuts. Attempts to determine whether fish used these reefs were unsuccessful. The trees set out in 1985 were inspected using SCUBA immediately after ice-out in the spring of 1986. They were in good condition, still had most of their needles and looked as though they would provide excellent cover for large and small fish. Fish were not observed occupying the reefs, but divers could see only a couple of feet due to turbidity. Any fish using the area probably were startled and avoided the divers. Several attempts at electrofishing over the reefs each spring, both at day and night, were unsuccessful.

Table 12. A list of Fort Peck Dam discharge conditions relative to the presence or absence of spawning walleye and sauger in the Missouri River at the U.S.G.S. cable crossing.

| | | March | | April | | May | | April-May | |
|---|---|---|---|---|---|---|---|---|---|
| | spawning run | avg.daily min.disch. | avg. disch. | avg.daily max.disch. | avg. disch. | avg.daily max.disch. | avg. disch. | avg.daily max.disch. | avg. disch. |
| 1988 | no | 3,117 | 6,942 | 6,991 | 6,013 | 8,395 | 6,939 | 7,686 | 6,484 |
| 1987 | no | 2,379 | 6,894 | 7,103 | 4,950 | 7,128 | 5,842 | 7,116 | 5,403 |
| 1986 | no | 1,602 | 6,261 | 8,827 | 7,027 | 7,642 | 6,319 | 8,225 | 6,667 |
| 1985 | yes | 3,740 | 7,526 | 12,920 | 10,613 | 16,008 | 14,039 | 14,489 | 12,354 |
| 1984 | yes | 4,674 | 7,990 | 9,856 | 7,673 | 12,530 | 9,497 | 11,215 | 8,600 |
| 1983 | yes | 5,079 | 8,761 | 9,497 | 6,870 | 9,346 | 6,555 | 9,430 | 6,703 |

## Northern Pike

### Abundance

The number of northern pike captured each year in the dredge cut trap nets has fluctuated widely (Table 13). The low count in 1987 may be partially explained by the short fishing time of the trap nets. The trend for northerns caught in the trap nets solidifies the evidence that water levels have a profound effect on the fishery of the area. In 1985, a relatively good water level year (Figure 4), when discharges were over the 4,500 cfs level for 60 percent of April and May (Table 11), more northerns were captured than in any other year. Northern pike require flooded vegetation in areas of calm, shallow water for spawning (Williamson 1942, Clark 1950). In May 1985, daily discharges from Fort Peck Dam were averaging around 14,000 cfs, and minimum daily discharges were dropping to about 9,000 cfs. These high discharge levels flooded much of the vegetation along the shores of the dredge cuts, providing good spawning habitat for pike. Since pike do not spawn at night (Clark 1950), spawning must have occurred when water levels were at or near their maximum daily levels. A YOY northern pike was captured in the dredge cuts in July 1985, indicating that minimum daily water levels remained high enough in the spring to maintain at least some spawning areas. For successful pike production, the spawning habitat must remain flooded, not only as eggs develop, but also through the embryo and fry stages (Frost and Kipling 1967, Hassler 1970). It is unlikely that northern pike successfully spawned in the study area in any year except 1985.

Table 13. Number, average length, average weight, and spawning condition of northern pike captured during spring trap netting in the Fort Peck dredge cuts, 1984-88.

| | | | | male | | female | | |
|---|---|---|---|---|---|---|---|---|
| | n | L | W | Rp | Sp | Gr | Rp | Sp |
| 1988 | 17 | 26.9 | 5.0 | 9 | 2 | - | 2 | 4 |
| 1987 | 2 | 26.9 | 4.7 | 1 | 1 | - | - | - |
| 1986 | 28 | 26.7 | 6.3 | 12 | 4 | 2 | 4 | 6 |
| 1985 | 57 | 25.6 | 4.6 | 35 | 3 | - | 17 | 2 |
| 1984 | 15 | 27.6 | 5.7 | 9 | - | 2 | 1 | 3 |

## Habitat Enhancement

The placement of Christmas trees in the dredge cuts did not directly benefit pike. The Christmas tree reefs were too deep to provide pike spawning habitat. Under the historic springtime discharge scenarios, which cause fluctuations up to two feet or greater each day, water levels are rarely stable enough to provide adequate spawning habitat long enough for northerns to successfully spawn, or for the eggs to successfully incubate and hatch. Also, native vegetation cannot establish in the fluctuation zone. The introduction of exotic vegetation which is resistant to water level fluctuations has not yet been seriously considered.

# Forage Fish

## Abundance

Previous work indicates that a lack of forage fish is a major factor limiting the development of a resident game fish population below Fort Peck Dam. The poor forage fish population is attributed to the daily water level fluctuations below the dam which creates an unstable zone along the shore where vegetation cannot establish. The only established shoreline vegetation in the study area is in the dredge cuts, near the upper edge of the fluctuation zone. This vegetation floods only at high water, and usually is dewatered at night.

In the past, small suckers were the most common forage species collected in the study area. Longnose, white and shorthead redhorse suckers all spawn in rocky riffle areas of streams (Brown 1971), and all three species have been observed in the East Side Channel in the spring while electrofishing for adult rainbow. Sucker eggs have been collected several times while sampling for rainbow eggs, and many small suckers are observed while sampling for YOY rainbow during late summer. Because of their spawning habits, suckers are affected by fluctuating water levels in much the same way as rainbow. Presumably, most of the small suckers collected in the dredge cuts were spawned in the river. Flooded shoreline vegetation in the dredge cuts appeared to be very important to these small suckers for rearing cover (Frazer 1985).

Better water level management and habitat enhancement has had some effect on the forage fish population below Fort Peck Dam during this study, but the DFWP's program to introduce new forage species into Fort Peck Reservoir had a greater impact.

The most important change seen in the forage fish situation below Fort Peck during this study was the large increase in cisco (Table 14).

Table 14. Number of forage fish captured in the Fort Peck tailrace and dredge cuts during standard seasonal gillnetting and seining, 1984-1988.

| | Cisco | Spottail Shiner | Rainbow Smelt | Emerald Shiner | Yellow Perch | Other |
|---|---|---|---|---|---|---|
| | | | Spring | | | |
| 1988 | 34 | 65 | 1 | 16 | 3 | 31 |
| 1987 | 25 | 117 | 2 | 29 | 10 | 256 |
| 1986 | 2 | 232 | 2 | 41 | 5 | 37 |
| 1985 | 0 | 6 | 1 | 24 | 4 | 37 |
| 1984 | -- | 271 | 0 | 98 | 9 | 263 |
| | | | Summer | | | |
| 1988 | 26 | 0 | 27 | 0 | 1 | -- |
| 1987 | 17 | 4 | 5 | 3 | 1 | 40 |
| 1986 | 33 | -- | 14 | -- | 3 | -- |
| 1985 | 4 | 14 | 0 | 3 | 11 | 2 |
| 1984 | -- | 1 | 10 | 25 | 2 | 12 |
| | | | Fall | | | |
| 1988 | 24 | 0 | 35 | 0 | 1 | 0 |
| 1987 | 63 | 3 | 2 | 1 | 0 | 1 |
| 1986 | 10 | 0 | 9 | 0 | 3 | 0 |
| 1985 | 1 | 0 | 0 | 0 | 2 | 0 |
| 1984 | -- | 0 | 9 | 0 | 0 | 0 |

Cisco were first planted as a new forage species in Fort Peck Reservoir in 1984 by MDFWP. Approximately 9.4 million cisco fry were planted in 1984, 10 million in 1985 and 14 million in 1986. Cisco spawning occurred in Fort Peck Reservoir each fall from 1985-1988 (Wiedenheft 1988), though 1987 was considered a poor year. The first live cisco were collected below Fort Peck Dam in 1985, and would have been mature enough to spawn that fall.

Young-of-the-year cisco were collected for the first time below Fort Peck Dam in 1986 during summer gill netting. Additional effort beyond the standard seasonal gillnetting included setting four monofilament gill nets in the upper dredge cuts and three in Nelson dredge in early September to sample for small cisco. A total of 133 YOY cisco were collected from these nets, indicating that large numbers of cisco were beginning to pass through the dam. Nine more YOY cisco were collected during the fall gill netting series. In early November, 1986 several hundred 5 to 7 inch cisco were found dead along the rip rap below the dam after a day of strong northwesterly wind. These fish apparently were killed or weakened while passing through the dam and forced into shore by wind action. In early February, about 2,000 dead cisco were concentrated along the riprap by strong winds. Local SCUBA divers and sportsmen reported finding dead cisco in the tailwater area all winter, indicating that numerous YOY cisco were passing through the dam during that winter. Since previous sampling showed that live cisco could pass successfully through the dam, it is likely that many of the cisco passing through in 1986 survived.

Bald eagles concentrate along the tailrace during the winter months to take advantage of the dead or injured fish which pass through the dam. U.S. Fish and Wildlife Service personnel counted 36 eagles in the study area in January 1988.

Spottail shiners were abundant some years. They also were introduced into Fort Peck Reservoir in 1982 and 1983 by MDFWP to improve the forage base. Seining results indicated they were well established in the reservoir by the fall of 1983 (Weidenheft 1984), and they continue to be the most abundant forage fish captured by beach seining. Since spottail normally occupy the shallow littoral areas of lakes, they were not expected to pass through the dam in any numbers. However, during spring seining in 1984, large numbers of spottail were collected in both the upper and Nelson dredge cuts, indicating they were indeed passing through the dam. In the fall of 1985, YOY spottail were collected by seining in all three ponds of the upper dredge cut, indicating that natural reproduction will occur below Fort Peck Dam. The large number of spottail sampled in 1986 showed that recruitment from natural reproduction and/or through the dam was good in 1985. No fall seining was conducted in 1986 to determine if spottail reproduction was successful. Spottail and suckers dominated the spring 1987 seine hauls. Shoreline seining in the fall of 1987 and spring of 1988 was futile, as the water levels were so low that no vegetation was

flooded. Less than 50 fish were captured in late 1987 and early 1988, though three or four YOY spottail were captured in the fall of 1987.

Both the spottail and the cisco have the potential to contribute significantly to the forage base below Fort Peck Dam. As their numbers increase in the reservoir, they will continue to pass through the dam to the downstream area. In years when conditions are favorable in the tailrace and dredge cuts area, forage fish production will be exceptional.

Rainbow smelt numbers were higher in the summer and fall of 1988 than in any other year. The last major smelt run occurred below Fort Peck Dam in 1980 (Needham and Gilge 1981). At that time 29 rainbow smelt were captured in 10 experimental gill nets set during the summer. The 1/2 inch monofilament nets were not used in 1980.

The spawning of emerald shiners, another important forage species in the area, is affected by fluctuating water levels even though these fish do not require flooded vegetation for spawning. Emerald shiners move into shallow water to deposit their demersal eggs over a sandy or firm mud bottom (Pfleiger 1975). Most of the shoreline of the dredge cuts provides good spawning habitat for emerald shiners, but because the eggs are deposited in shallow water, they are subject to desiccation when water levels fall.

Yellow perch are collected in the dredge cuts, though spring seining and trap netting results never show the population to be large. Yellow perch require littoral vegetation (either aquatic or flooded terrestrial) and stable water levels for spawning (Clady and Hutchinson 1975). In the spring of 1985, the Big Muddy Sportsman Club transplanted approximately 15,000 ripe perch from the Dredge Cut Trout Pond to the upper dredge cuts. At that time, water levels were high enough in the dredge cuts to flood some vegetation and provide perch spawning habitat. The capture of yearling perch in 1986 indicated that some spawning was successful. Big Muddy Sportsman planned on moving more perch in the spring of 1986, but weather conditions apparently interrupted perch spawning in the Trout Pond, and no perch were collected.

It is evident that the forage fish population below Fort Peck Dam is strongly coupled to the water level fluctuations in the area. Attempts to establish vegetation in the fluctuation zone have been futile. Local native vegetation such as bulrush and cattail cannot overcome the magnitude of fluctuations in most years.

## Habitat Enhancement

The DFWP expected its recommendations for minimum discharges from Fort Peck Dam to provide some benefits for forage fish. When the COE maintained minimum spring discharges at the recommended level as they did during most of the spring in 1985, enough shoreline vegetation was flooded to provide spawning habitat and security cover for forage fish. Minimum daily water levels remained high enough in 1985 to allow some successful perch production. Although minimum daily discharges in 1986 were maintained above the absolute recommended minimum level (4,500) on only 21 days during the 3 month spring period, they still were above historic spring levels. As a result, more shoreline remained flooded, reducing the likelihood that eggs deposited in shallow water would be dewatered. This improved the chances of successful reproduction of shallow spawners such as the emerald shiner and spottail shiner.

The Christmas tree reefs placed in the dredge cuts in the spring of 1986 were intended to provide both spawning habitat and security cover for forage fish. The trees were placed in 7 - 13 feet of water. Yellow perch are reported to spawn in 3 - 12 feet of water as long as they have flooded vegetation or other substrate on which to spawn (Krieger, Terrell & Nelson 1983). With the low water levels and lack of flooded shoreline vegetation in the dredge cuts in 1986-88, the Christmas tree reefs provided the best perch spawning habitat available. However, successful spawning was never documented. Because of the depth at which they were located, these trees were not subject to dewatering even when water levels dropped. Eggs deposited on them had a good chance of survival. The trees also provided the only dependable security cover in the dredge cuts.

## Chinook Salmon

Chinook salmon were first planted below Fort Peck Dam in the spring of 1983 in an attempt to develop a spawning run in the tailwater area. Hasler et. al. (1978) reviewed the documentation of homing in Pacific salmon. Plants have occurred annually since 1983, but the development of a spawning run has not yet occurred (Table 15). Survival of the eyed eggs planted in 1987 was 23 percent, which translated into 10,810 fry.

The angler harvest of some adult fish in the tailrace and the discovery of a few redds in the area are at best circumstantial evidence that spawning occurs. Adult chinook in the tailrace and dredge cuts may have passed through Fort Peck Dam rather than migrated upstream from Garrison Reservoir, and the redds located in 1987 and 1988 may have been constructed by brown trout, which is another fall spawning salmonid that inhabits the area. Yearling

brown trout have been collected from the dikes in the East Side Channel. An experienced chinook angler from Oregon identified the redd he saw in 1987 to be that of a chinook, but chinook were never observed on or near any of the redds.

The habitat enhancement completed for rainbow also was designed to provide spawning and rearing habitat for chinook if a spawning run does occur. The capture of planted chinook near the dikes indicates that naturally produced chinook would probably use these structures for rearing.

Table 15. Number, stage of development, and location of plants of chinook salmon below Fort Peck Dam, 1983-87.

| | Number | Stage of Development | Location | Return * |
|---|---|---|---|---|
| 3/83 | 45,000 | 3-5 inch | tailrace | 3 adults harvested |
| 3/84 | 216,000 | 3-5 inch | tailrace | 1 redd |
| 3/85 | 105,000 | 3-5 inch | tailrace | 3 redds |
| 3/86 | 94,000 | 3-4 inch | tailrace | fall 1989 |
| 12/87 | 47,000 | eyed egg | new gravel in East Side Channel | fall 1990 |

* Evidence of returns is circumstantial at best. Adult chinook may have passed through the dam into the tailrace and been harvested by anglers. Brown trout also inhabit the study area and may have built the redds located each fall. An experienced chinook angler from Oregon stated that he thought the redd he saw in the fall of 1987 was that of a chinook.

## Potential Long Term Plans

In the 1986 milestone report a large scale habitat enhancement project involving the construction of weirs in both the main west channel and the east side channel was described (Frazer 1986). The final report for the project was completed by the GEOMAX consulting firm in 1986 (Baxter 1986). This study determined that it would be necessary to raise the base surface elevation of the tailpool 0.8 feet to maintain a minimum flow of 300 cfs in the East Side Channel during normal low discharges. This would provide near optimum spawning and rearing conditions for rainbow in the side channel, and could be accomplished with the construction of a small underwater weir in the west channel near the lower end of Scout Island. Due to the minimum size requirement of material needed to construct a stable structure in this area, this weir would be approximately 15 feet wide, 1.5 to 2 feet high and span the entire channel. This type of structure would raise the base surface elevation of the tailpool approximately 1.5 feet. To reduce peak flows in the east channel to less than 1,000 cfs, this preliminary plan also called for the construction of a weir in the east channel. The structure was to contain 11 36-inch culverts and one baffled 48-inch culvert to allow low flows to pass through and to facilitate fish passage.

When this plan was initially proposed, the consultants thought this type of project would reduce or totally eliminate daily water level fluctuations in the tailpool and dredge cut area. This would have been extremely beneficial to the fisheries in the area, and it would have helped mollify serious bank erosion problems. But after analyzing all flow and water fluctuation data, the consultants determined that the plan would not reduce these daily water level fluctuations in the tailpool or dredge cuts, but would raise the base surface elevation by 1.5 feet. This would have serious negative impacts on the downstream area. Bank erosion already is a serious problem in the tailpool and dredge cut area even though the banks have reached some equilibrium with existing water level fluctuations. A rise of 1.5 feet in the base surface elevation with the same magnitude of fluctuations would cause a drastic increase in shoreline erosion until the banks readjusted to the new water level. Additional land would be lost, and the siltation problem in the East Side Channel would intensify. Higher water levels also would inundate most of the swimming beaches in the dredge cuts. These problems and a cost higher than originally estimated made this plan unfeasible.

One over-riding factor that must be considered is the overwintering of pallid sturgeon in the tail race area. A flow control structure in the west channel may inhibit pallid access to the deep holes that they seem to prefer immediately below the dam. Although GEOMAX did not know about the pallid at the time of their report, they did state that water velocities in the west channel would remain unchanged if the structure was built as designed, so fish passage should not be a interrupted.

The siltation problem documented in the East Side Channel by this study indicates that high flushing flows are needed to help keep spawning gravel clean, and that a method of preventing these sediments from entering the channel is needed. The sources of the sediment have been identified, and sediment control dams have been designed for the implementation of a program to prevent sediment entry into the stream. Funding shortfalls within the COE have prevented the construction of these dams to date, but they are annually programmed into the Natural Resources budget of the Fort Peck Project.

## RECOMMENDATIONS

The habitat improvements made in the study area have exhibited mixed results. The number of rainbow trout redds constructed each year has more than doubled since the beginning of the study. Egg survival has increased dramatically, and the resulting young-of-the-year are using the introduced rearing cover to avoid daily lateral migrations that use to be necessary to maintain their position relative to favorable current velocities. The energy that they save can now be put toward growth rather than spent on movement.

Establishment of spawning and rearing habitat in the dredge cuts met with less success. The magnitude of the daily water level fluctuations is too great to be overcome by native vegetation. Conditions are similar to when the study began. Production of forage fish depends almost entirely on the magnitude of the daily fluctuations. The placement of Christmas tree reefs has provided some spawning and rearing habitat, and the passage of some species through Fort Peck Dam contributes to the forage base of the tail race and dredge cuts.

The presence of a walleye or sauger spawning run seems to be closely coupled with the relative discharge regimes of Fort Peck Dam and the Milk River.

To maintain the improvements gained and to continue to develop the area for gamefish, several requirements must be met. They are-

1) discharges from Fort Peck Dam must meet or exceed the discharge recommendations of MDFWP.

2) construct the sediment check dams to prevent the entry of fines into the East Side Channel.

3) biannually inspect and sample the rainbow spawning gravel, and replace those areas where sediments less than 6.35 mm diameter comprise over 20-25 percent of the substrate.

4) annually inspect the cover in the rainbow spawning and rearing area, and place logs and tree trimmings into the area to provide adequate and diverse rearing cover.

5) continue the rainbow redd counts weekly from April 15 through June 7.

6) design and construct a buffer in the dredge cuts to stabilize water levels.

7) biannually construct artificial reefs in the dredge cuts for spawning and rearing of forage fish, and continue efforts to establish vegetation in and below the fluctuation zone for spawning and rearing habitat for forage fish and young gamefish.

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Appendix Table 1. Percent composition of substrate samples collected in 1988 in the rainbow trout spawning areas in the East Side Channel of the Missouri River at Fort Peck.

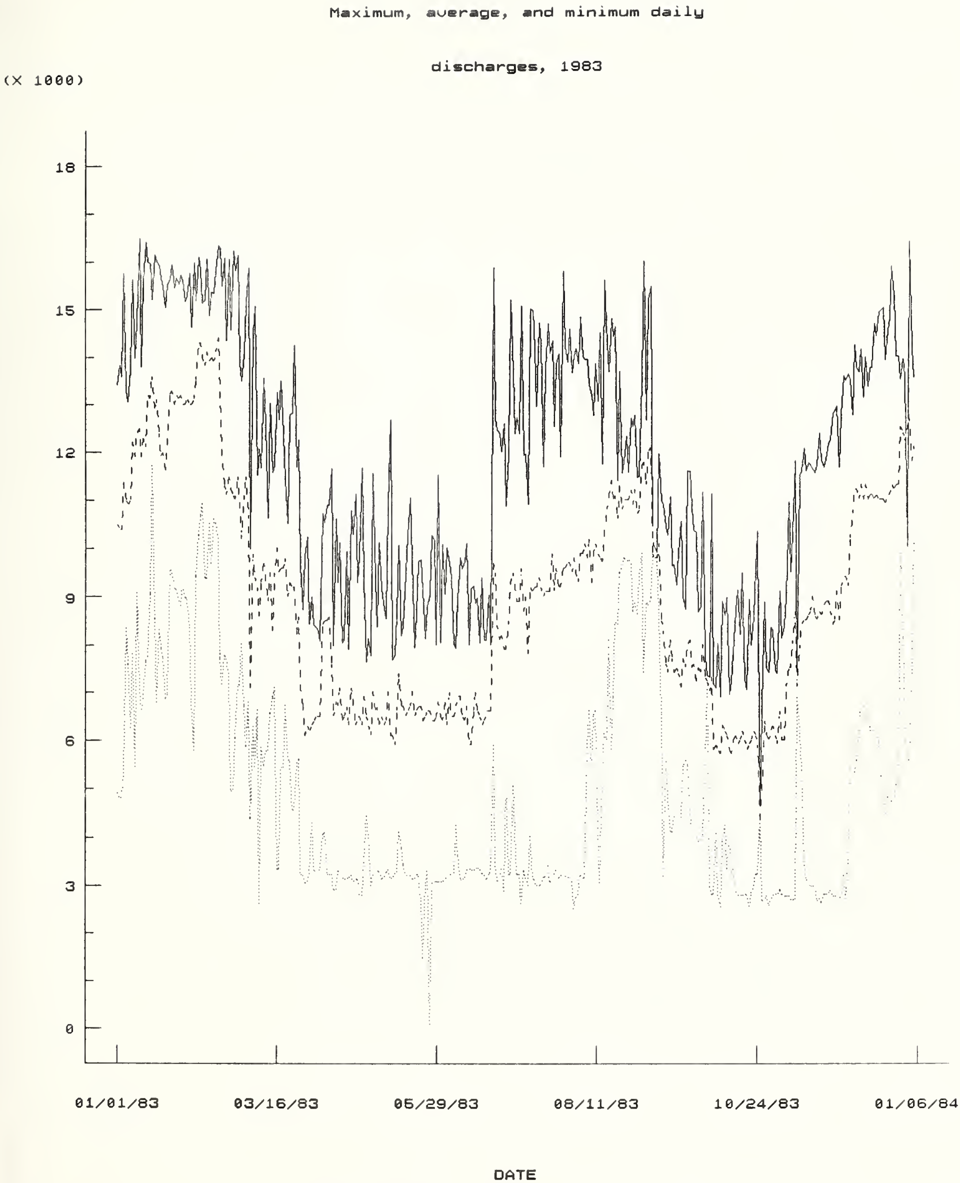
| Sample weight (grams) | Percent in various size classes (mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | >63.5 | 25.4-63.5 | 12.7-25.4 | 6.35-12.7 | 2.0-6.35 | 0.074-2.0 | cone* |
| 1985 Gravel | | | | | | | |
| 16,414 | 26.7 | 24.0 | 14.7 | 5.4 | 7.3 | 21.4 | 0.6 |
| 11,989 | 25.2 | 52.1 | 17.5 | 0.6 | 0.2 | 2.2 | 2.3 |
| Composite | 25.6 | 38.1 | 16.1 | 3.0 | 3.8 | 11.8 | 1.5 |
| 1987 Gravel | | | | | | | |
| 13,623 | 0 | 43.6 | 29.8 | 20.8 | 4.0 | 0.8 | 1.0 |
| 18,608 | 0 | 31.4 | 29.4 | 7.6 | 3.6 | 24.7 | 3.3 |
| 17,356 | 0 | 28.1 | 46.5 | 14.9 | 0.3 | 2.6 | 7.5 |
| 18,481 | 0 | 18.3 | 47.4 | 21.8 | 1.7 | 3.0 | 7.9 |
| Composite | 0 | 30.4 | 38.3 | 16.3 | 2.4 | 7.8 | 5.0 |

Continued.

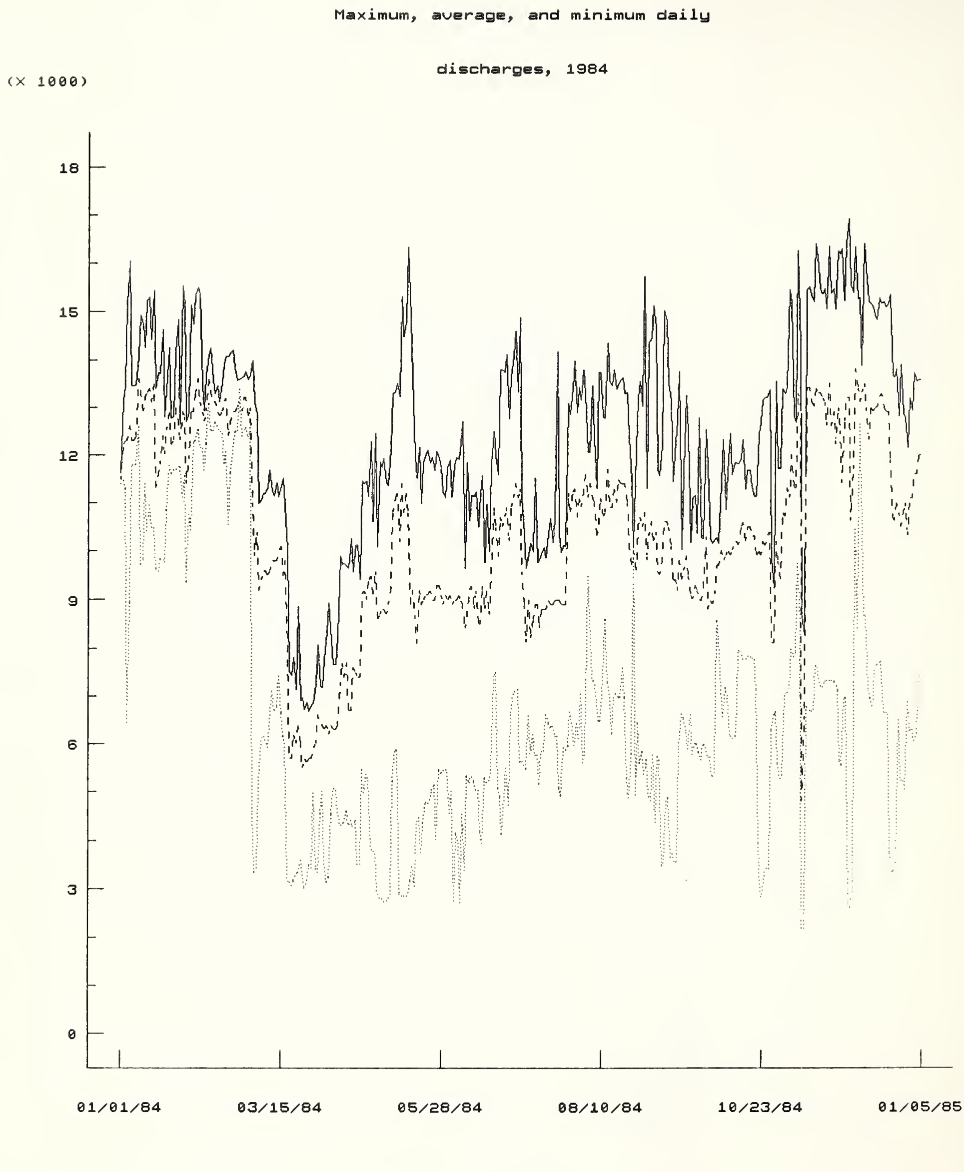
Appendix Table 1. Continued.

| Sample weight (grams) | Percent in various size classes (mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | >63.5 | 25.4-63.5 | 12.7-25.4 | 6.35-12.7 | 2.0-6.35 | 0.074-2.0 | cone* |
| | | | Natural Gravel | | | | |
| 18,944 | 10.3 | 35.7 | 20.4 | 9.9 | 9.3 | 12.9 | 1.5 |
| 10,526 | 24.6 | 33.7 | 18.3 | 7.2 | 8.7 | 7.3 | 0.2 |
| 16,383 | 42.0 | 17.2 | 10.4 | 8.1 | 10.0 | 11.3 | 1.0 |
| 17,245 | 5.4 | 33.6 | 13.0 | 11.4 | 13.7 | 22.7 | 0.2 |
| Composite | 20.6 | 30.1 | 15.5 | 9.2 | 10.4 | 13.6 | 0.7 |

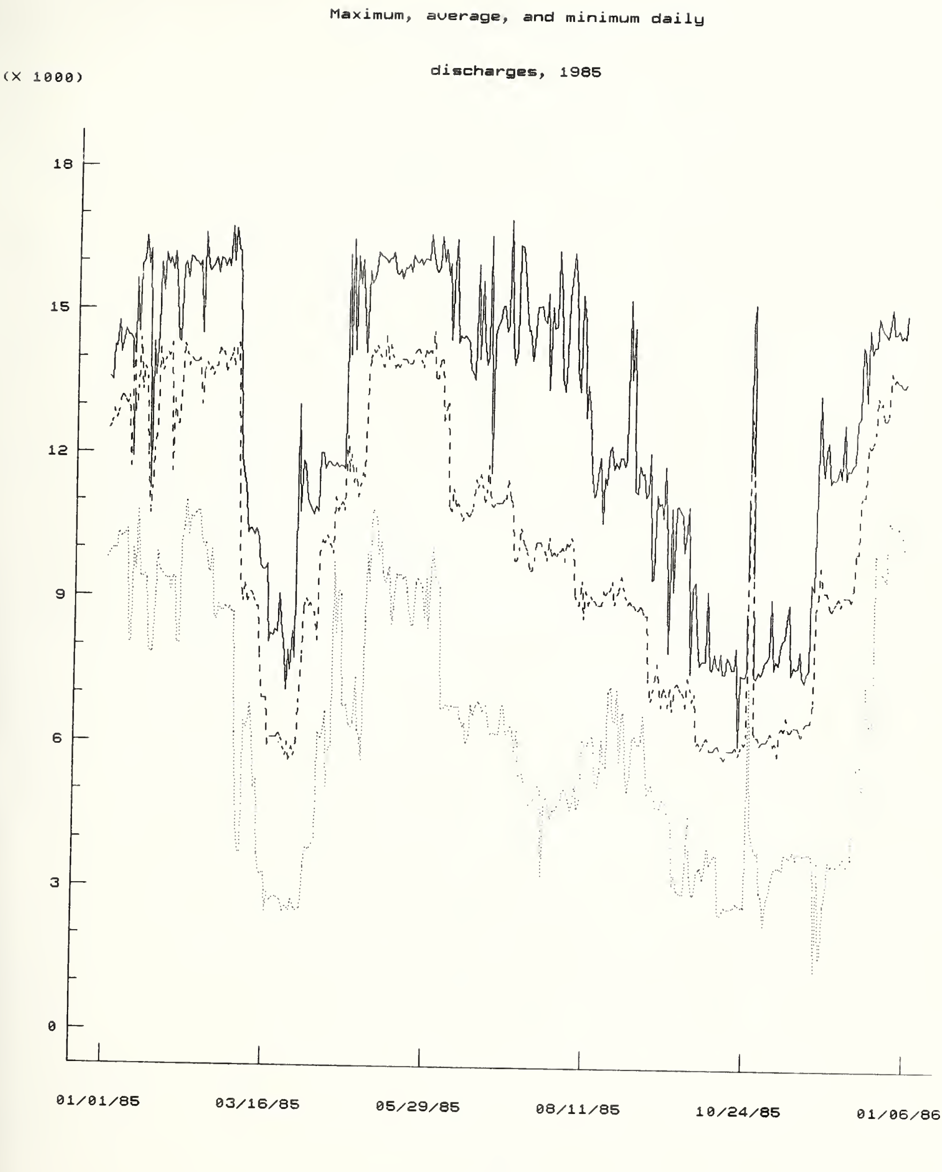
* The cone measures particles < 0.074 that are suspended in the water inside the sampler.



Appendix Figure 1. Annual Hydrographs. continued



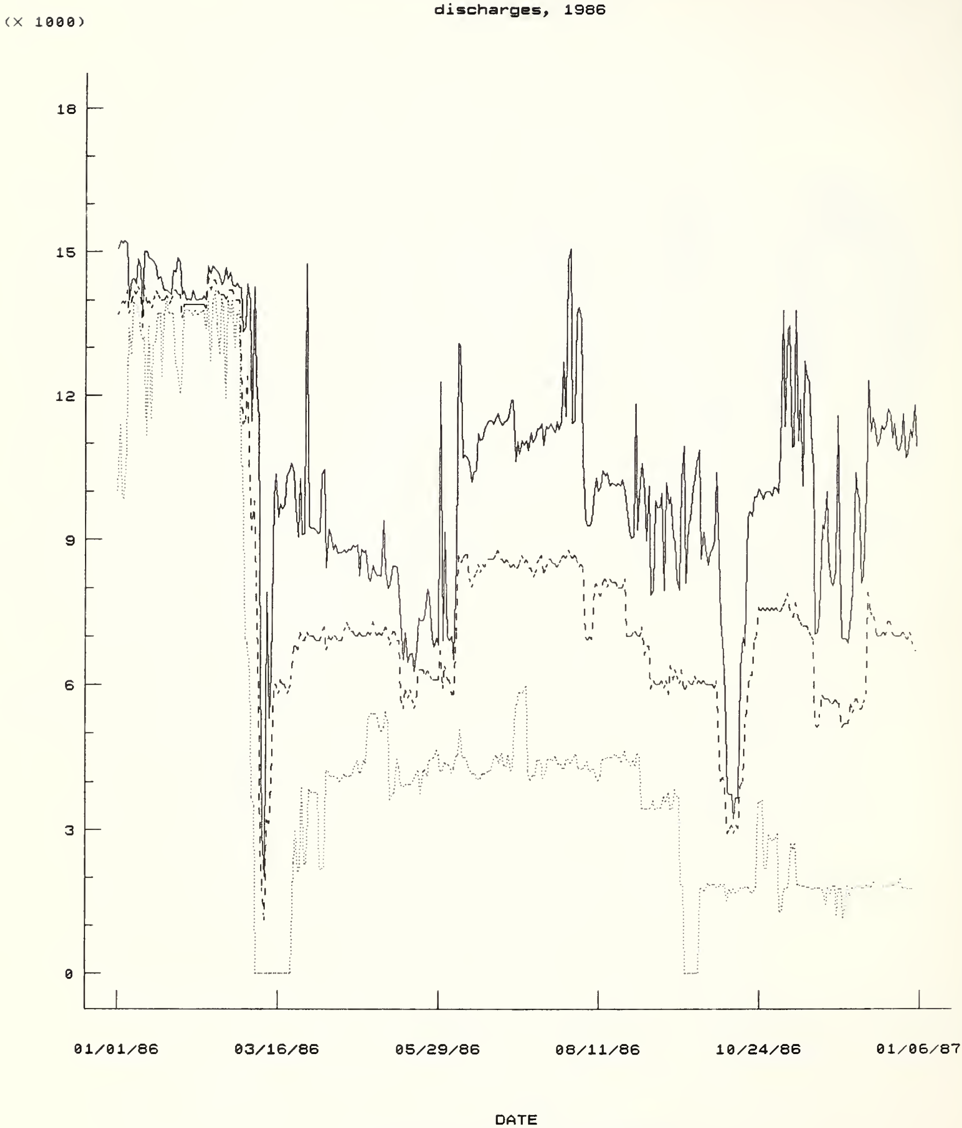

Appendix Figure 1. Continued.



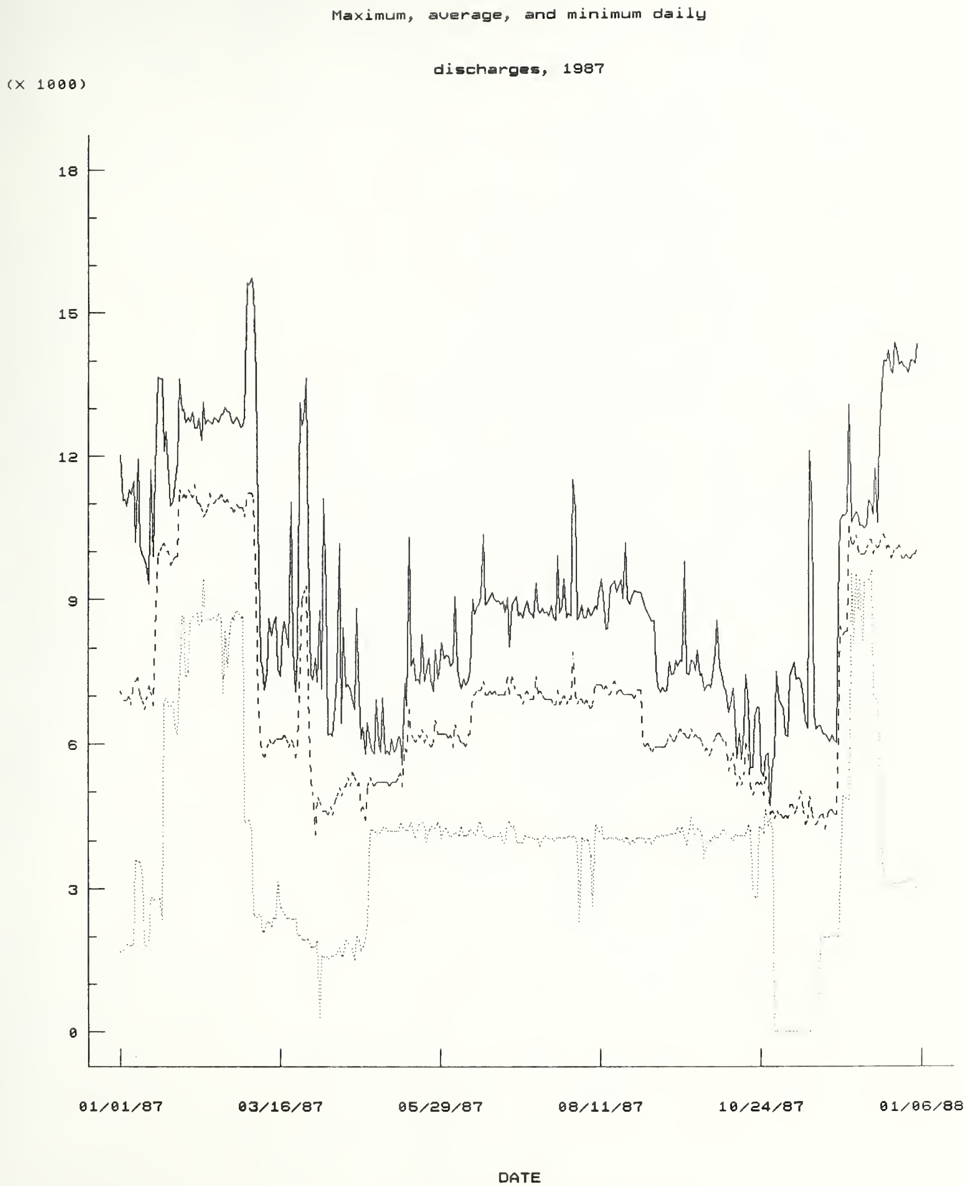

Appendix Figure 1. Continued.

Maximum, average, and minimum daily

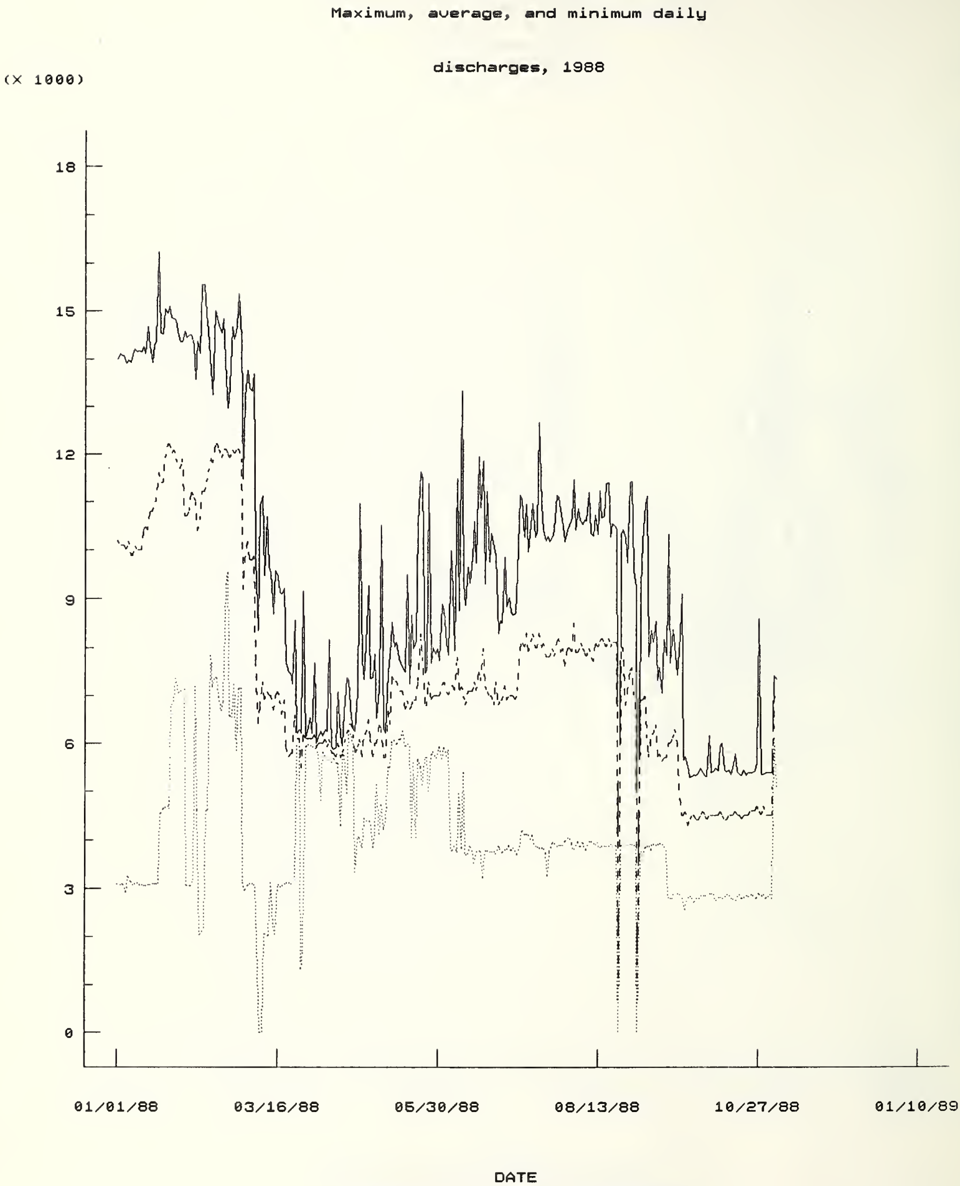
discharges, 1986




Appendix Figure 1. Continued.




Apppendix Figure 1. Continued.



Appendix Figure 1. Continued.